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TRANSACTIONS
OF
American Microscopical Society

(Published in Quarterly Installments)

Vol. XXXVI OCTOBER, 1917 No. 4

SUMMARIES IN MICRO-BIOLOGY

The Secretary has been seeking to secure for this Journal and its Department of Summaries, a series of papers from biologists dealing with the chief groups of microscopic plants and animals. It has not been the purpose to present a complete survey of any of the groups. The wish has been rather to bring together in one article a statement of the following things:—general biology, the method of finding, the methods of capture and of keeping alive and cultivating in the laboratory; how best to study; the general technic; the most accessible literature; and a brief outline of the classification, with keys for the identification of at least the more representative genera and species of the micro-organisms likely to be found by the beginning students in the United States.

It has been felt that the getting together of such data as this, while not a contribution to science, would be a contribution especially to isolated workers and to teachers and students in the high schools and smaller colleges.

Papers have already appeared treating the aquatic Oligochetes, the Melanconiales, the Rusts, the Black Moulds, the Powdery Mildews, the Cephaline Gregarines, the Conjugate Algæ, and the Free-swimming, Fresh-water Entomostraca. The following is the ninth paper of the series. It is proposed to have such synopses from time to time until the more common American species of such groups as the following have been covered: The non-conjugating Green Algæ, Downy Mildews, Yeasts, other Hyphomycetes, Smuts, Rhizopods, Infusoria, Turbellaria, Bryozoa, Water Mites, etc. [Editor.]

SYNOPSIS OF THE BLUE-GREEN ALGÆ —MYXOPHYCEÆ

By Josephine E. Tilden

The Myxophyceæ (Cyanophyceæ, Schizophyceæ) in structure and function are the simplest and most primitive of Algæ. They are deserving of study for several reasons. In some ways at least they appear to be somewhat closely related to the Bacteria. Having the advantage of larger size and more definite structure their life histories and habitats are of interest to students of bacteriology and medicine. They are of economic importance in connection with the problem of pure water supplies for cities. Geologists now consider that large existing deposits of marl, travertine and silicious sinter are the result of the work of these minute plants. To students and teachers of botany the study of the blue-green algæ forms a useful introduction to the higher forms.

Collecting Blue-green Algæ

The common Blue-green algæ are to be searched for in ponds, in small pools on swampy ground or along roadsides, on moist and dripping rocks, at the edges of lakes and rivers. Along the seashore they will be found in tide-pools, on rocks, and clothing the fronds of larger algæ. Some of these algæ are able to live in hot waters and a study of the vegetation of hot springs and geysers forms an interesting problem.

It is usually not difficult to find sufficient material for class use even in the winter months, in springs, on dripping rocks, or at any rate in tanks and vessels in green houses. It is, however, easier to preserve specimens when they are found in abundance and so have them on hand when needed. To collect them one needs some wide-mouthed vials, a knife or scalpel for scraping damp boards and rocks, a spoon for dipping minute floating forms from the water. If one desires to preserve the specimens for future microscopic work, they should be immediately placed in vials containing a 2 or 3 per cent formaline solution. A descriptive label should be inserted in each vial, containing date of collection and notes on habitat, color, form, locality, etc. On the other hand, specimens designed to be kept alive in the laboratory for class work should be transferred as soon as possible from the collecting vials to broad glass tanks or jars which should stand in or near a north window where they will not receive too much sunlight. It is well to cover these jars with glass plates.

If one desires to determine the species of these algæ it is necessary to possess an eyepiece micrometer or a micrometer disc (which fits inside standard eyepieces).

Structure

During the last few years a number of investigators have given their attention to determining the nature of the protoplast of the Blue-green algæ. The majority of them now consider that there is a definite cell wall, an "incipient nucleus," cytoplasm, and three main pigments.

The cells in this group consist of a protoplasmic mass surrounded by a wall or membrane and containing a single "incipient nucleus." Protoplasmic connections between cells have been demonstrated in certain cases. In an actively growing condition the protoplasm fills the cell. In long continued dryness it contracts away from the wall. Young growing cells contain many granules, but when older their contents become homogeneous. The cytoplasm contains chlorophyll, phycocyanin, and carotin (pigments), several kinds of granules, a slime substance, vacuoles, oil-drops, glycogen and sugar. Probably sugar is the first product of photosynthesis. The sugar is changed into glycogen as a carbohydrate reserve. Starch is not found in the Blue-green algæ. The cyanophycin granules are a product of assimilation and represent reserve albumen.

True chromatophores are not present. The green chlorophyll combined with the bluish phycocyanin give the characteristic blue-green color to the cells of these plants. Red or pink tints are due to the predominance of carotin. The chlorophyll and carotin appear to exist in the form of very minute granules, while the phycocyanin occurs in a diffuse state. To the age of the cell and the color of the sheath is due the difference in the color of the protoplasm in different parts of the same plant. It is generally more greenish in young parts which are covered by a colorless sheath, while in older ones it is olive or yellowish-green. Sometimes the terminal cells of a trichome, in certain genera, show a rose-colored tint.

By the use of various stains it has been found that each cell contains a single nucleus, the so-called "central body." It is much simpler than the nucleus of other plants, since it possesses neither a nucleolus nor a nuclear membrane, and the best descriptive term now in use seems to be "incipient nucleus." The resting nucleus consists of a slightly staining ground mass in which numerous granules lie imbedded. These granules are not true chromatin but nothing much so far is known about them. During cell division the incipient nucleus seems to divide without mitosis. It constricts and the new cell-wall first appears as a ring midway between the daughter-nuclei. This becomes gradually filled in towards the center until the wall between the two daughter-cells is complete.

At first the cell wall is composed principally of cellulose. Later it becomes changed in character, resembling fungus-cellulose or the cuticle of higher plants. It may in some cases contain silica and in others chitin. The outer portion is mucilaginous. Blue-green algæ in all cases secrete mucilage and are usually found imbedded in masses of mucus. In filamentous plants the mucus forms an enveloping "sheath" which may dissolve and become invisible, or in other cases may undergo a toughening process. Such a sheath is a secretion of the cells of the plant.

The heterocyst is a special cell usually larger than the ordinary cells. It is formed from a vegetative cell by the breaking down of the incipient nucleus, a loss of the granular character of the cell contents, and the thickening of the cellulose wall. The position of the heterocyst in the trichome varies, sometimes it being confined to the end of the row of cells, and in other cases it lies between two ordinary cells. Although usually colorless, the watery contents of the heterocyst sometimes have a more or less decided yellowish tint. Heterocysts are usually solitary but they may occur in short chains.

While it is a fact that the function of the heterocyst is at present not at all understood, it is doubtless concerned with the breaking up of the trichome into hormogones. By some it is considered to act as a storehouse for reserve substances.

In the unicellular forms the terms "plant" and "cell" are synonymous. Therefore when the cell divides the result is not *growth* but *multiplication*, for two distinct new plants have been formed. In all other cases the cells cling together after division and are arranged in rows or strings. The "plant," then, consists of a row of cells. The entire number of cells in a blue-green multicellular plant (including heterocysts and gonidia if present) taken together, is known as the "trichome." In many genera the trichome is surrounded by a gelatinous sheath or envelope. The trichome together with its sheath is called the "filament."

In the multicellular forms the plant grows by the transverse division either of all the cells, as in Nostoc, or of a group of cells occupying a definite position, as in Rivularia. Ordinarily division takes place as soon as the cell has attained its maximum size; but under favorable conditions secondary divisions occur in the young cells and when this happens the cells are much shorter than broad, that is, the cross walls appear quite close together.

Reproduction

In the unicellular forms multiplication is the result of simple cell division. In some genera gonidia, formed within gonidangia, occur.

The multicellular Blue-green algæ reproduce commonly by means of hormogones. A hormogone is a short chain or row of cells broken off from a mature plant. For a short time it has the power of motion. Its cells rapidly divide and thus a new plant is developed.

A second method of reproduction in the multicellular forms, is by means of gonidia. These are either formed within gonidangia, or, as is most commonly the case, developed from vegetative cells into thick-walled resting cells.

Water-Supply Algæ

A number of species belonging to the Blue-green Algæ are of interest because of their effect upon drinking water.

Some of these algæ possess a natural odor and taste, due to the presence of an oil, which upon being liberated produces a most disagreeable result. The odor is like raw green corn, or still more disagreeable. In others no particular odor is noticeable while the plants are alive, but when the water dries up leaving the algæ to die, a "pig-pen odor" is given off and the water remaining in the pool is unfit to be used for drinking purposes by animals. This effect is the result of the breaking down of highly organized compounds of sulphur and phosphorus in the presence of the large amount of nitrogen which these plants contain.

The question of how to keep drinking water pure is creating much interest at the present time. Water Boards and Boards of Health in large cities are establishing laboratories where chemists, botanists and bacteriologists may carry on study and investigation under the best advantages. Experiments are being made to discover the best methods of building reservoirs so that light may be shut off and the water kept free from organic matter, for algæ require light and nutriment for their development.

Thermal Algæ

In general all living things are soon killed when subjected to high temperatures, but certain kinds of algæ are able to exist in water heated almost to the boiling point. Blue-green algæ are almost the only kinds found in hot waters. In the hot springs and geysers of Yellowstone Park, those of Iceland, New Zealand, Japan, tropical Africa, Carlsbad, Arkansas and California, are found these plants. True hot water algæ are those living in water of a temperature ranging from 40° to about 75° C. The upper limit of temperature is not determined exactly at present.

Calcareous Algæ

All green land and water plants—that is, all plants containing chlorophyll—take in carbon dioxide gas, making the carbon and some of the oxygen atoms into new compounds for themselves, setting free the rest of the oxygen atoms. The calcium bicarbonate in water is held in solution by carbonic acid gas. Then anything that causes the withdrawal of the carbonic acid will cause the lime carbonate to be precipitated. Certain algæ, in some way that we can not explain, have this power of withdrawing carbonic acid from the water in which they live. As the plants grow they become encased in calcareous sheaths. Perhaps the colony begins to develop on a piece of shell. The filaments radiate outwards in all directions, each independent of the others and all precipitating calcium carbonate tubules. Gradually a pebble of lime is formed looking like an ordinary water-rounded pebble. These algal calcareous pebbles show both radial and concentric structure. The bluish-green radial lines are probably formed by growth of filaments. The concentric lines may represent seasonal or annual periods of growth of plants. These pebbles have been found in several marl lakes in Michigan and in a Minnesota lake. Sometimes, also, blue-green algæ form calcareous layers instead of rounded masses or pebbles.

Calcareous hot waters are rare in Yellowstone Park, the one locality where deposits of travertine have been formed being Mammoth Hot Springs. The travertine deposit here is about two miles in extent. The thickness of the deposit is variable but is not known to exceed two hundred and fifty feet. There are about seventy-five springs. The red, orange and green colors on the overflow slopes are due to the presence of microscopic algæ. This deposit of travertine is formed chiefly by the activities of algæ in withdrawing carbon dioxide from the water, thus separating carbonate of lime.

The four Geyser Basins of Yellowstone Park are characterized by the large amount of silica contained in solution by the hot waters. They are the Norris, Upper, Middle and Lower Basins. Their waters are alkaline. It is not yet known just how the algæ cause the precipitation of silica from the hot water.

Family Chroococcaceæ

These plants are unicellular, that is, each individual consists of a more or less spherical mass of protoplasm, faintly tinged with bluish-green or purple tints. The wall is usually gelatinous. The plants exist in an isolated condition or they live together in masses or colonies imbedded in the gelatinous substance secreted from the outer layer of their walls. The common method of multiplication is by simple cell division in one, two or three directions. In Synechococcus division takes place in one direction only and the daughter-cells remain clinging to one another for a brief period—thus indicating the origin of the trichome or row of cells. In Merismopedia the plants form flat, plate-like colonies. The individual plants are arranged very regularly in the plate, as a result of division taking place in two directions only. In Aphanothece and Glœocapsa, division takes place in three directions, so that the colony formed is approximately spherical.

These plants grow in moist places on rocks, on tree trunks, or in pools. Many of them are covered by a thick envelope of gelatine which enables them to endure dryness for a long time.

Merismopedia violacea sometimes forms rose-colored fragile masses on the bottom of fish tanks or pools.

Microcystis æruginosa is a common pest in many city water reservoirs during the hot summer months. Cœlosphærium is also a common species in city water supplies. The colony is gelatinous, spherical and hollow. The small, globose, blue-green plants lie in the peripheral portion immersed in the gelatine. They may be scattered or lie in pairs or in fours.

Family Oscillatoriaceæ

Each trichome is a single plant. Numbers of them form a soft, filmy dark bluish-green or blackish layer. Some species live in salt water, but they are particularly common in fresh water stagnant pools, in ditches, on wet ground, around pumps, cisterns and tanks, and are often seen as a coating on the inside of wooden watering troughs.

In structure these plants are the simplest of the filamentous forms. The trichome is straight or somewhat curved, cylindrical, composed of a single row of cells placed end to end. In some species the individual cells are slender and longer than wide, forming a very thin hair or thread. In other species the cells are broad and short, and the plant then appears to be made up of a series of discs placed face to face. The plant is in general cylindrical in shape, but often, according to the species, it may taper either gradually or abruptly at each end. The end, or apical cell itself, has a characteristic shape in the different species. It must always be remembered, when trying to determine the species of these plants, that they break apart very easily, thus leaving *broken ends* which of course do not show the specific characters of the true apical cell.

In some species a row of granules will be seen on either side of the common wall.

The family, Oscillatoriaceæ, takes its name from the fact that certain algæ belonging to it have the power of motion. The movement is a peculiar one and as yet not at all understood. The plant may move through the water with a gliding motion; it may oscillate or vibrate; or it may merely bend or wave back and forth at one extremity, the other end being apparently attached to some object in the water.

These plants have no heterocysts and no gonidia. They reproduce only by means of hormogones. The plant separates into short segments consisting of a few cells each. These short segments are motile for a time and are known as hormogones. The cells composing them begin dividing at once and the hormogone soon attains the size and appearance of the parent plant.

It is an alga in this family, Trichodesmium erythræum, which has caused the Red Sea to be so named. It floats in the surface waters, giving them a red color.

Family Nostocaceæ

To this family belong such common plants as Nostoc, Anabæna, and Cylindrospermum. They are simple in structure, all the cells of the trichome being somewhat similar in size, shape and appearance. The plants are not attached but are isolated or they live in gelatinous colonies. The sheath surrounding the trichome is either gelatinous or mucilaginous, and may or may not be visible. The heterocysts occur at intervals in the trichome, or they may be terminal. The intercalary heterocysts have two thickened cellulose buttons at the point of attachment to the adjoining cells. These are wanting in the terminal heterocysts. When a Nostoc plant forms hormogones, the sheath softens, allowing the segments of the trichome to escape into the water. To determine genera and species, the position, form, size and color of the gonidia must be noted. The character of the wall, as well as the relation of the gonidium to the heterocyst, must be also taken into consideration.

Nostoc colonies generally occur as more or less rounded masses, varying from the size of a pea to that of a plum. Anabæna and Cylindrospermum form yellowish or bluish-green layers. It is very important to note that the individual *plants* in these three genera resemble each other very closely. Before beginning the study of the microscopic characters, one must determine whether the colony has a definite form or whether it occurs merely as a layer without definite shape.

Some of these plants live inside the tissues of higher plants—in the roots of Cycas, in the leaves of Azolla, in the fronds and rhizoids of Liverworts.

Family Scytonemaceæ

The filaments (plants) have a base and an apex and are generally branched. In Scytonema the branches arise in the middle of the interval comprised between two heterocysts. In Tolypothrix the branches depart from the sheath immediately below a heterocyst. The branches may be solitary or in pairs ("twin" branches). The method of branching, known as "false" branching, is somewhat peculiar. The growth area occurs midway between two heterocysts where the cells will be found to be shorter and more crowded. Since the heterocysts are stationary within the sheath, the increase in the number of cells and the growth in length of the individual cells create a strong pressure at this middle point, and it is here that the sheath will finally give way, allowing the trichome to form a loop outside. With further growth this ruptures at the bend, so that in general "twin" false branches are formed. In other cases only one branch may continue to grow, the other remaining undeveloped. Hormogones, with rounded extremities, may be found within the sheath in many plants. The sheath is tubular and continuous. It may be colorless or it may be brownish or yellowish. The heterocysts are intercalary or basal, solitary or in series. Gonidia have been seen in some species.

Family Stigonemaceæ

The most important characteristic of this family is the formation of true branches. This is effected by a division of the cells in a direction parallel to that of the main axis. The branch arises by a development of one of the lateral cells. Thus, a certain lateral cell divides in the longitudinal direction of the plant body, instead of transversely. Growth continues in this direction so that there is formed, projecting at right angles to the main filament, a single row of cells which is a "true" branch. In species in which the trichome consists of a single row of cells the heterocyst occupies the place of an entire cell. When the cells divide longitudinally and there are several longitudinal rows within the sheath, the heterocyst stands in the place of one of the lateral peripheral cells. In certain species having a very strongly colored sheath, they are but slightly apparent. In general the heterocysts are smaller than the ordinary cells and have a brighter, more yellowish color. Hormogones are formed at the ends of branches or in special short branches.

Family Rivulariaceæ

The plants in this family are distinguished from other forms of the class by the trichome terminating in a hair. In other words the plant is wider at the basal portion and tapers towards the apex.

The series of cells forming the apical portion, or "hair," contain little protoplasm and are not capable of further growth. The cells are long, slender, straight and colorless. When hormogones are produced this "hair" falls away. Heterocysts are sometimes wanting. Sometimes only basal ones exist. Sometimes in the same species there are both basal and intercalary heterocysts. The plants are sometimes simple and sometimes they form false branches. Branching results generally through the growth of the summit of the lower segment of the trichome, just below an intercalary heterocyst. Rarely the trichome breaks out in the interval between two heterocysts (most frequently at the base of old plants of Calothrix). Then the branches resemble those of Scytonema. Sometimes the branches break immediately from the main filament. Sometimes they remain inside the sheath.

The sheath is tubular, continuous, gelatinous, or membranaceous, homogeneous or lamellose. The interior layers are often capable of much swelling. Sometimes particles of lime are deposited upon the sheath. Then the colony becomes transformed into a stony mass. The sheaths are colorless or tinted with yellow or brown. Gonidia are known in but few cases. These are generally submerged plants.

MYXOPHYCEÆ

The Myxophyceæ are typically blue-green, the coloring matter being a mixture of two pigments, chlorophyll and phycocyanin; pigments of other colors sometimes present.

The plant body is unicellular or multicellular, sometimes endowed with a peculiar motion; plants existing usually in gelatinous masses, sometimes solitary among other algæ.

Reproduction is always asexual, either by simple cell division in one, two or three directions of space, or by means of hormogones (multicellular fragments of the plant body, at first motile, afterwards coming to rest), or by means of non-motile gonidia formed within gonidangia, or by means of resting gonidia formed from ordinary cells.

Habitat: Plants are found in fresh, brackish or salt water, in hot springs, in mineral springs, in ærial situations, or as endophytes.

Order I. **Coccogoneæ.** Plants unicellular, single or associated in families or colonies which are usually surrounded by a copious gelatinous

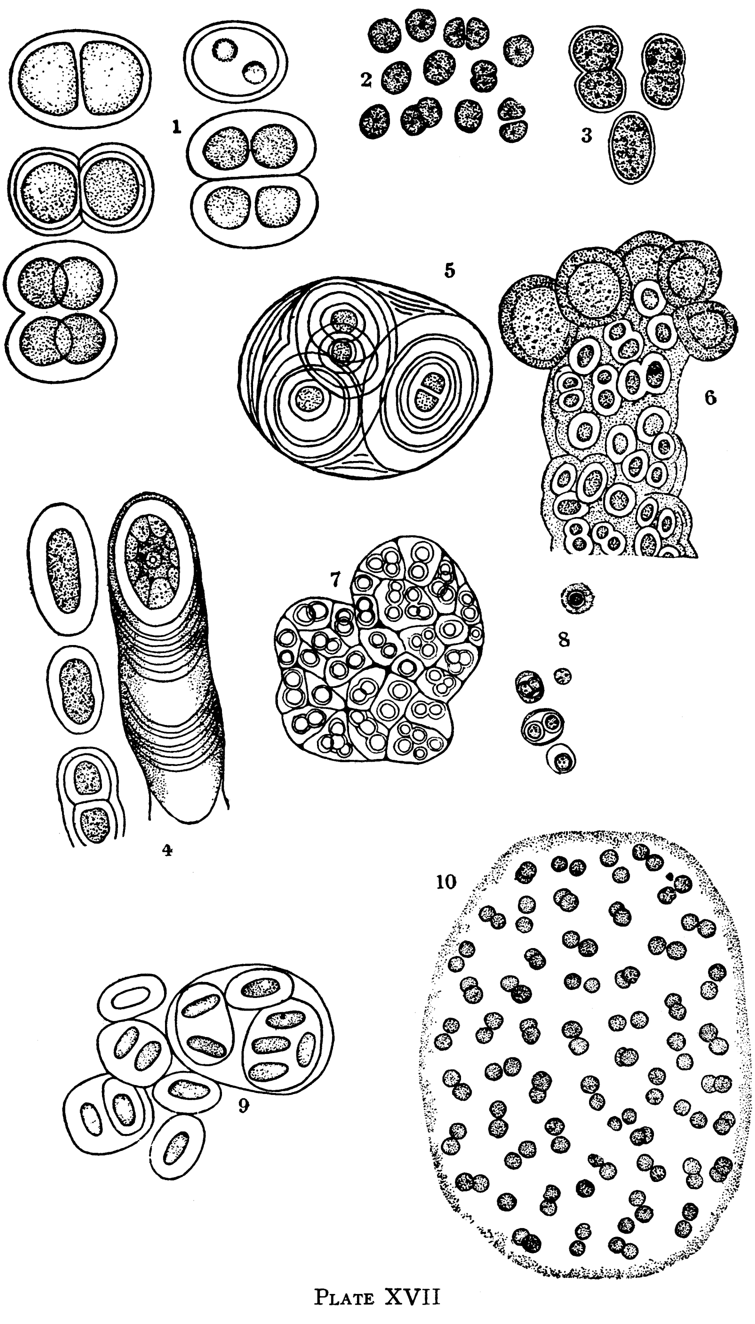


Plate XVII

integument, rarely forming filaments; reproduction occurs commonly by the vegetative division of cells, rarely by the formation of non-motile gonidia from the division of the contents of a gonidangium (mother-cell).

Order II. **Hormogoneæ.** Plants multicellular, filamentous, attached to a substratum or free-floating; filaments simple or branched, usually consisting of one or more rows of cells within a sheath; reproduction occurs by means of hormogones or resting gonidia. Page 209.

Order I. COCCOGONEÆ

Family I. **Chroococcaceæ.** Plants showing no difference between basal and apical regions, solitary or associated in families or colonies; reproduction by vegetative division of cells in one, two or three directions of space.
Family II. **Chamæsiphonaceæ.** Plants often showing a difference between basal and apical regions, solitary or associated in families or colonies, usually epiphytic or attached to shells; reproduction by means of non-motile gonidia formed by the division of the contents of a mother-cell (gonidangium). Page 205.

Family I. CHROOCOCCACEÆ

I. Plants solitary or associated in small, indefinite families or colonies, not surrounded by a common (colonial) gelatinous tegument
  1 Cells spherical; reproduction by cell division in three directions **Chroococcus** Plate XVII, Fig. 1
  2 Cells spherical; reproduction by cell division in one direction only **Synechocystis** Fig. 2
  3 Cells oblong, ellipsoidal or cylindrical; sheath wanting; reproduction by cell division in one direction only **Synechococcus** Fig. 3
  4 Cells cylindrical or oblong-conical; sheaths thick, hyaline; reproduction by cell division in one direction only **Chroothece** Fig. 4
II. Plants associated in families or colonies, surrounded by a common gelatinous tegument
  1 Colonies without definite shape
    (1) Individual sheaths usually thick, remaining through many divisions, sheath of original mother-cell surrounding entire colony

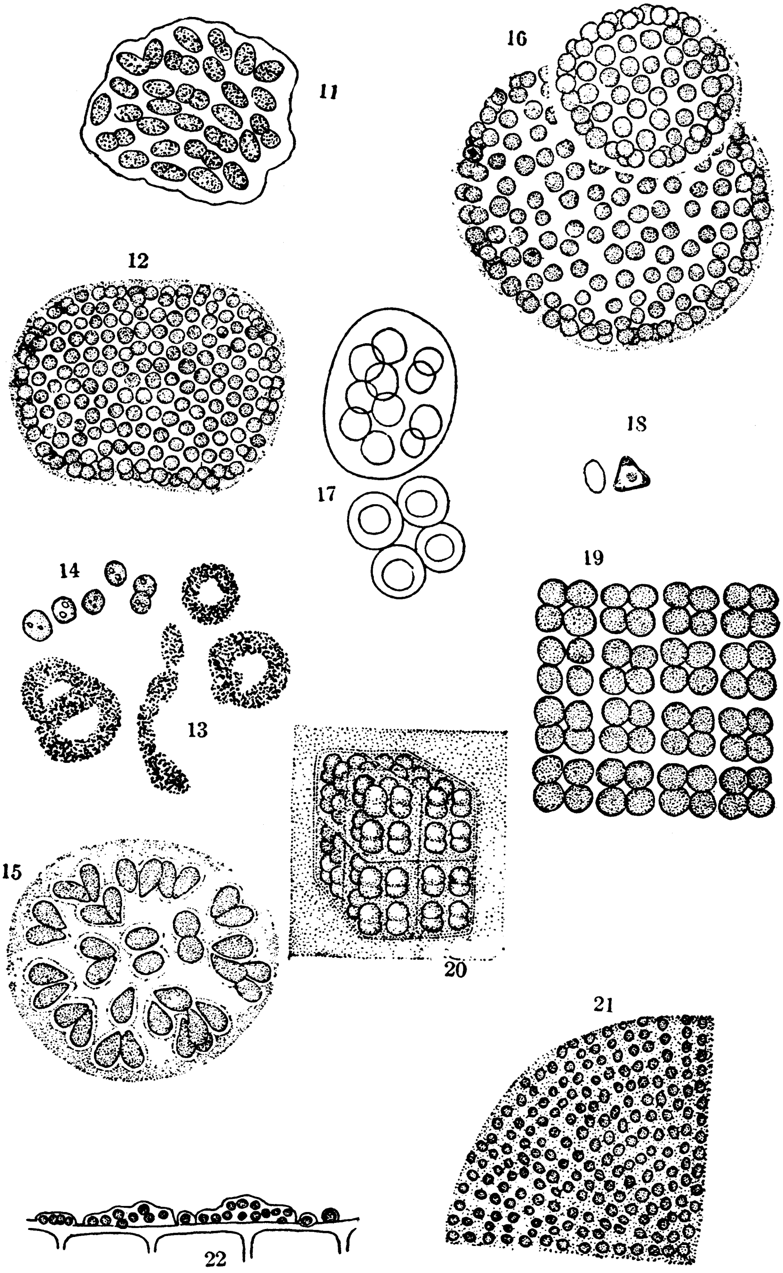


Plate XVIII

A Cells spherical
  a Cells enclosed in a vesicle-like, thick, colorless or colored sheath, spherical (after division oblong), single or in colonies: cell contents blue-green, or of various colors **Glœocapsa**
Fig. 5
  b Cells surrounded by an elliptical membrane, forming colonies, arranged in short filaments **Entophysalis**
Fig. 6
  c Cells surrounded by thick sheath, forming spherical colonial masses; plant mass cushion-like, cartilaginous, incrusted with lime at base, curled at periphery **Chondrocystis**
Figs. 7, 8

B Cells elongate
  a Cells cylindrical-oblong, surrounded by a thick, mucous sheath, solitary or forming small colonies **Glœothece**
Fig. 9

(2) Individual sheaths not distinct; colony surrounded by common tegument formed of dissolved individual sheaths

A Cells spherical (or angular from mutual pressure); cell division in all directions **Aphanocapsa**
Fig. 10

B Cells oblong; cell division in one direction **Aphanothece**
Plate XVIII, Fig. 11

2 Colonies having a definite characteristic shape
(1) Colonies free-floating

A Cells having an indefinite arrangement, forming several layers
  a Cells spherical or oblong; colony spherical or oblong, solid **Microcystis**
Fig. 12
  b Cells spherical; colonies of variable shape, at first solid, becoming saccate and clathrate **Clathrocystis**
Figs. 13, 14
  c Cells pear-shaped or heart-shaped; colony spherical or ellipsoid, solid **Gomphosphæria**
Fig. 15

B Cells having a definite arrangement, forming a single layer or cube
  a Colonies spherical, hollow

(a) Cells spherical, lying just within the periphery of the colony **Cœlosphærium**
Fig. 16

(b) Cells spherical or elongate; individual sheaths distinct **Cœlosphæriopsis**
Fig. 17

b Colonies flat

(a) Cells of some definite or symmetrical shape, quadrangular or triangular, solitary or forming colonies **Tetrapedium**
Fig. 18

(b) Cells spherical; colonies rectangular **Merismopedium**
Fig. 19

c Colonies cubical, solid; cells spherical or elliptical **Eucapsis**
Fig. 20

(2) Colonies adherent to substratum

A Cells spherical or elongate, regularly arranged in radial rows; colonies cushion-like, hard, leathery, verrucose **Oncobyrsa**
Fig. 21

B Cells spherical or oval, irregularly arranged in radial rows; colonies irregularly lobed, epiphytic **Chloroglœa**
Fig. 22

Genus CHROOCOCCUS

Plate XVII, Fig. 1

Plants either free-floating or forming a gelatinous or crust-like plant mass in damp places, in fresh or salt water, or within the tissues of other plants, occurring as spherical or angular cells, each surrounded by a more or less definite sheath, solitary or united in twos, fours, eights, etc., but not held together in definite colonies by a common gelatinous tegument; sheaths thin or wide, homogeneous or lamellose, colorless or colored; cell contents homogeneous or granular, usually of a blue-green color, sometimes violet, olive-green, orange or yellowish; reproduction by successive division of the cells alternately in three directions of space.

I. Sheaths hyaline, often lamellose; cell contents orange or yellowish.

1 Cells less than 3 mic. in diameter **C. rubrapunctus**

2 Cells more than 15 mic. in diameter

(1) Plant mass yellowish green; cells 25-50 mic. in diameter **C. macrococcus**

(2) Plant mass orange-colored; cells 19-34 mic. in diameter **C. turicensis**

II. Sheaths hyaline, yellowish or brownish, often lamellose; cell contents blue-green, rarely olive-brown, reddish-green, brownish-violet or copper-red

- 1 Cells not embedded in a gelatinous mass, mostly solitary among other algæ
  - (1) Sheaths thick, distinctly lamellose; cell contents blue-green
    - A Sheaths colorless; cells 13-25 mic. in diameter **C. turgidus**
    - B Sheaths yellowish or brownish; cells 5.8-11 mic. in diameter **C. schizodermaticus**
  - (2) Sheaths not lamellose
    - A Cells 5-7 mic. in diameter **C. minutus**
    - B Cells 1.7 mic. in diameter **C. multicoloratus**
    - C Growing in hot water; cells 1-1.5 mic. in diameter **C. thermophilus**
- 2 Cells embedded in a gelatinous mass, not free-floating
  - (1) Sheaths lamellose
    - A Sheaths slightly lamellose; plants 4-8 mic. in diameter **C. varius**
    - B Sheaths lamellose, finally irregularly peeling off; plants 6-11 mic. in diameter **C. decorticans**
  - (2) Sheaths not lamellose, sometimes scarcely visible
    - A Plants 5 mic. in diameter, mostly subquadrate, often triangular, rarely multiangular; sheaths scarcely perceptible **C. refractus**
    - B Plants 4-7.5, rarely 9 mic. in diameter, spherical **C. helveticus**
    - C Plant mass pale yellowish; sheaths oblong-elliptical; cells 7.5-13 mic. in diameter; cell contents blue-green, yellowish or orange **C. pallidus**
    - D Plant mass green, later becoming black; sheaths distinct, ellipsoid; cells 2.7-6.6 mic. in diameter; cell contents blue-green **C. cohærens**
    - E Plant mass blue-green or olive; sheaths scarcely visible; plants 3-4 mic. in diameter; cell contents blue-green **C. minor**
    - F Plant mass lead-colored or green becoming black; sheaths thick, mucous; plants 3-8 mic. in diameter; cell contents blue-green **C. membraninus**

- 3 Cells embedded in a gelatinous, free-floating mass
  - (1) Plants 8-13 mic. in diameter, much crowded; cell contents green or blue-green **C. limneticus**
  - (2) Plants 13 mic. in diameter, usually in groups of two; groups lying apart from each other; cell contents grayish-purple **C. purpureus**

Genus **SYNECHOCYSTIS**

Plate XVII, Fig. 2

Plants always globose; sheaths none; cell walls thin not diffluent; cell contents blue-green; reproduction by division of the cells in one direction only.

Submerged; plants 5-6 mic. in diameter, single or in pairs; cell walls hyaline, very thin; cell contents pale blue-green. **S. aquatilis**

Genus **SYNECHOCOCCUS**

Plate XVII, Fig. 3

Plants oblong, cylindrical or ellipsoidal, usually single, occasionally forming families of two or four united in a row or chain; sheaths none; cell walls thin; cell contents blue-green, sometimes yellowish, pinkish or pale orange; reproduction by division of the cells in one direction only.

- I. Cell contents blue-green
  - 1 Cells 7-15 mic. in diameter, 14-26 mic. in length **S. æruginosus**
  - 2 Cells 2 mic. in diameter, 4-6 mic. in length **S. racemosus**
  - 3 Growing in hot salt water; cells 3 mic. in diameter, 6 mic. in length **S. curtus**

Genus **CHROOTHECE**

Plate XVII, Fig. 4

Plant mass somewhat gelatinous, dark-yellowish; plants cylindrical or oblong-conical, with rotund ends, single or in pairs; sheaths wide, lamellose, hyaline, increasing greatly in thickness at one pole; cell contents distinctly granular, bright blue-green or orange-yellow; reproduction by division of the cells in one direction only.

- I. Plants 18-24 mic. in diameter **C. richteriana**
- II. Plants 1.5 mic. in diameter **C. cryptarum**
- III. Plants 11-12.5 mic. in diameter **C. monococca**

Genus **GLŒOCAPSA**

Plate XVII, Fig. 5

Plants spherical (or immediately after division oblong), either single or a number associated in families; each cell enclosed in a vesicle-like, strongly thickened, usually distinctly lamellose sheath; sheaths often very thick, colorless or colored, usually lamellose; lamellæ often peeling off; cell contents blue-green, bluish, steel-blue, reddish, yellowish, etc.; reproduction by division of the cells alternately in three directions.

When a cell divides into two daughter-cells, each one secretes a sheath about itself, the two still being enclosed by the sheath of the mother-cell. As division goes on, the sheath of the original cell remains enveloping the entire family, and in fact all the sheaths remain in existence. Therefore, there will always be one less than twice as many sheaths as there are cells in the family (in a family of four cells there will be seven sheaths; in a family of sixteen cells there will be thirty-one sheaths). Later generations of cells are smaller than the first ones.

I. Sheaths colorless
  1 Sheaths lamellose
    (1) Sheaths wide
      A Plant mass steel blue, green, olive or dull yellow; plants 7-8 mic. in diameter; sheaths very wide, indistinctly lamellose; cells 3-5 mic. in diameter **G. granosa**
      B Plant mass dull green or olive; plants 3-4.5 mic. in diameter; sheaths very thick, with numerous concentric lamellæ **G. polydermatica**
      C Plant mass green; plants 7-15 mic. in diameter; sheaths very thick, more or less distinctly lamellose; cells 2.2-3.4 mic. in diameter **G. fenestralis**
      D Plant mass somewhat olivaceous; plants 6-17 mic. in diameter; sheaths thick; cells 3.7-6 mic. in diameter **G. arenaria**
    (2) Sheaths narrow
      A Plant mass pale yellow becoming greenish; growing in hot water; plants 19-39 mic. in diameter; cells 3-6 mic. in diameter **G. montana**
      B Plant mass mucilaginous, dull green or gray becoming blackish, or red becoming brownish; plants 7-11 mic. in diameter; cells 3-4.5 mic. in diameter **G. quaternata**
      C Plant mass a calcareous crust, light gray or green; plants 6-9 mic. in diameter **G. calcarea**

D Plant mass gelatinous, brownish, growing on Zostera; sheaths numerous, distinct; cells 9-11 mic. in diameter, 19-26 mic. in length **G. zostericola**

2 Sheaths sometimes lamellose
 (1) Plant mass blue-green or greenish; sheaths not distinctly lamellose
  A Free-floating; cells .75-2.8 mic. in diameter **G. punctata**
  B On wet rocks; plants 4-8 mic. in diameter; cells 2-3 mic. in diameter **G. æruginosa**
 (2) Plant mass olive or green; plants 6.2-10 mic. in diameter; sheaths narrow, lamellose when old; cells 2.5 mic. in diameter **G. gelatinosa**
 (3) Plant mass dull olive; plants 7-11 mic. in diameter; sheaths thick, not at all or scarcely lamellose; cells 3-6 mic. in diameter **G. conglomerata**

3 Sheaths not lamellose
 (1) Plant mass flesh-colored to yellowish; plants 2.5-5.5 mic. in diameter; cell contents flesh-colored to honey-colored **G. mellea**
 (2) Plant mass black; plants 9-14 mic. in diameter; cells 3.5-4.5 mic. in diameter; cell contents pale blue-green **G. atrata**

II. Sheaths yellowish or brownish
1 Sheaths lamellose
 (1) Plant mass dull olive to brownish-green; sheaths colorless or yellowish **G. muralis**
 (2) Plant mass grayish-brown to black; sheaths very thick, yellowish or orange, becoming darker **G. rupestris**

2 Sheaths sometimes lamellose
 (1) Plants 4.5-5.5 mic. in diameter; sheaths usually not lamellose; cells 1.5-2 mic. in diameter **G. fusco-lutea**
 (2) Plants 12 mic. in diameter; sheaths homogeneous or lamellose; cells 3-4.5 mic. in diameter **G. sparsa**
 (3) Colonies subglobose; sheaths somewhat lamellose; cells 9-15 mic. in diameter **G. gigas**

3 Sheaths not lamellose; plant mass olive-green; plants 5-8 mic. in diameter **G. crepidinum**

III. Sheaths violet, purple or red
  1 Sheaths lamellose
    (1) Plant mass purple, sometimes becoming black
      A Sheaths deep purple or copper-brown; plants 6-12 mic. in diameter **G. magma**

      B Sheaths violet or reddish-purple; plants 7.5-12 mic. in diameter; cells 2-4.5 mic. in diameter **G. janthina**

      C Sheaths very thick, opaque, intensely lamellose; plants 10-17 mic. in diameter; cells 4-7 mic. in diameter **G. ralfsiana**

  2 Sheaths sometimes lamellose; plant mass colorless or dark purple, growing in hot water; plants 6-7.8 mic. in diameter; cells 1-2.6 mic. in diameter **G. thermalis**

  3 Sheaths not lamellose
    (1) Plant mass violet becoming gray or black
      A Plants 4-8 mic. in diameter; sheaths violet, thick, often opaque; cells 1.8-2.5 mic. in diameter **G. ambigua**

      B Plants 10-17 mic. in diameter; sheaths violet or rose-colored; cells 3.5 mic. in diameter **G. violacea**

    (2) Plant mass reddish-orange, dark red or black
      A Plants 11-24 mic. in diameter; sheaths very thick, soon peeling off **G. dubia**

      B Sheaths intensely blood-red, very wide; cells 3.5-9 mic. in diameter **G. sanguinea**

Genus ENTOPHYSALIS

Plate XVII, Fig. 6

Plant mass globose, cartilaginous, including numerous, more or less confluent small families of cells; cells spherical, each surrounded by an elliptical sheath, associated in families.

I. Plant mass crustaceous; cells 2-5 mic. in diameter **E. granulosa**

II. Plant mass mucous; cells 4-6 mic. in diameter **E. magnoliæ**

Genus CHONDROCYSTIS

Plate XVII, Figs. 7, 8

Plant mass cushion-shaped, widely expanded, up to 35 cm. high, cartilaginous, soft, fragile, encrusted with lime at the base, curled up at periphery; families consisting of spherical masses of cells lying free, the membranes of which seem to be thickened into one layer.

Plant mass rose-colored to red, thick; cells somewhat spherical or elongate, 2 mic. in diameter, 3-5 mic. in length; sheath thick. **C. schauinslandii**

Genus GLŒOTHECE

Plate XVII, Fig. 9

Colonies embedded in a common gelatinous tegument; cells cylindrical-oblong, rounded at the ends, each surrounded by a wide mucous homogeneous or lamellose sheath; reproduction by transverse division of the cells in one direction only.

I. Individual sheaths colorless
  1 Cells .8-2.5 mic. in diameter, 10.5-18 mic. in length **G. linearis**
  2 Cells 1.6-3 mic. in diameter, 2.2-7.5 mic. in length **G. confluens**
  3 Plants 8-12 mic. in diameter, 12-36 mic. in length; cells 4-5.5 mic. in diameter, 6-15 mic. in length **G. rupestris**
  4 Cells 4-5 mic. in diameter, 6-10 mic. in length **G. membranacea**
  5 Cells 2.5-2.7 mic. in diameter, 4.8-5.7 mic. in length, somewhat crescent-shaped with acute apices **G. lunata**
II. Individual sheaths partly or entirely colored
  1 Plant mass usually free-floating
    (1) Sheaths colorless at margins; cells 3-4 mic. in diameter **G. magna**
    (2) Sheaths usually brownish or yellowish; cells 4-5.5 mic. in diameter, 6-11 mic. in length **G. fuscolutea**

Genus APHANACAPSA

Plate XVII, Fig. 10

Plant mass more or less expanded, colorless or blue-green, yellow or brown; plants spherical or angular from mutual pressure, single or in pairs; individual sheaths thick, very soft, colorless, not distinct, confluent into a mucous, amorphous, homogeneous colonial tegument; tegument colorless or tinted brown or blue-green; reproduction by successive division of the cells alternately in three directions.

I. Plant mass colorless
  1 Cells 1.5-2 mic. in diameter **A. elachista**
  2 Cells 10-16 mic. in diameter **A. zanardinii**

II. Plant mass green or blue-green
  1 Plant mass globose, gelatinous, dirty green; cells 3.2-5.6 mic. in diameter **A. grevillei**
  2 Plant mass hemispherical, gelatinous, blue-green; cells 5-6 mic. in diameter **A. rivularis**
  3 Plant mass amorphous, gelatinous, dirty green or olive **A. virescens**

III. Plant mass brown
  Cells 4.5-5.5 mic. in diameter **A. brunnea**

Genus **APHANOTHECE**

Plate XVIII, Fig. 11

Plant mass more or less expanded, somewhat spherical or without definite shape; individual sheaths thick, not distinct, confluent into a mucous, amorphous, homogeneous colonial tegument; cells oblong; reproduction by division of the cells in one direction only.

I. Plant mass without definite shape
  1 Cells 1-2 mic. in diameter **A. saxicola**
  2 Cells more than 2 mic. in diameter
    (1) Plant mass dirty green or olive brown; cells 2.5-3 mic. in diameter **A. conferta**
    (2) Growing in very salt water; cells 5 mic. in diameter, hardly longer than broad **A. utahensis**
    (3) Cells one to three times as long as broad
      A Plant mass colorless; cells 4-4.5 mic. in diameter **A. microscopica**
      B Plant mass colored
        a Plant mass blue-green, olive or yellowish-brown; cells 2-3.5 mic. in diameter **A. castagnei**
        b Plant mass pale blue-green; cells 3-8 mic. in diameter **A. pallida**
        c Plant mass pale yellowish-green or olive; cells 2-3 mic. in diameter **A. microspora**
        d Plant mass yellowish-brown or olive; cells 4-4.5 mic. in diameter, irregularly scattered **A. nægelii**

II. Plant mass more or less spherical
  1 Plant mass pale blue-green; cells 3-5 mic. in diameter **A. stagnina**
  2 Plant mass bright or dark emerald green; cells 5-6.5 mic. in diameter **A. prasina**

Genus MICROCYSTIS

Plate XVIII, Fig. 12

Colonies spherical or somewhat spherical, solid, finally becoming hollow and lobed, single or associated in clusters, containing large numbers of cells, surrounded by a colorless, gelatinous tegument; cells spherical, oval or elliptical; cell contents green or blue-green, often showing vacuoles; reproduction by cell division in three directions.

I. Cells spherical

1 Colonies more or less spherical, usually containing several daughter colonies each surrounded by its own tegument; cells 2-4 mic. in diameter **M. ichthyoblabe**

2 Plant mass dull yellowish becoming olive; colonies 30-70 mic. in diameter; cells 2.2-4 mic. in diameter **M. donnellii**

3 Colonies spherical, flattened, orbicular, lens-shaped, sometimes confluent, surrounded by a thick, lamellose common tegument; cells 3-4 mic. in diameter **M. marginata**

4 Colonies more or less spherical or oblong, with an indistinctly limited tegument, pale or yellowish-green; cells 4-6.5 mic. in diameter **M. flos-aquæ**

II. Cells oval or oblong, sometimes almost spherical

1 Colonies spherical, oblong or flattened, sometimes containing several daughter colonies each surrounded by its own tegument; cells 1-1.5 mic. in diameter, 3-5 mic. in length, oblong **M. elabens**

2 Plant mass pulverulent, bright glaucous or whitish blue-green; colonies spherical or oblong; cells 2-3 mic. in diameter, somewhat spherical or oval **M. pulverea**

3 Plant mass irregular, firm, gelatinous, pink, brown or green, growing in very salt water; cells 2.5-4 mic. in diameter, 6-7 mic. in length, oblong or elliptical **M. packardii**

4 Plant mass mucous, floccose, amorphous, sky-blue; colonies somewhat spherical, distinctly limited; cells somewhat spherical or ellipsoid (size unknown) **M. piscinalis**

5 Colonies irregular in shape, with an indistinctly limited tegument; cells 5-5.5 mic. in diameter, spherical or oval **M. pallida**

Genus CLATHROCYSTIS

Plate XVIII, Figs. 13, 14

Colonies of variable shape, at first solid soon becoming saccate and clathrate, ("fragments of the broken fronds occurring in irregularly lobed forms"), surrounded by a colorless, gelatinous, indistinctly limited integument; cells spherical, numerous.

I. Cells 3-4 mic. in diameter, spherical **C. æruginosa**

II. Cells 6-9 mic. in diameter, spherical or oval **C. robusta**

Genus GOMPHOSPHÆRIA

Plate XVIII, Fig. 15

Colonies spherical or ellipsoid, mucous, solid, free-swimming; tegument colorless or yellowish, usually thick, soon diffluent; cells pear-shaped or heart-shaped, rarely somewhat spherical, grouped in pairs, few in numbers, disposed chiefly towards the periphery of the tegument; cell contents often granular, bluish or greenish; reproduction by cell division alternately in three directions.

I. Cells 4-5 mic. in diameter, 8-12 mic. in length **G. aponina**

II. Cells 3.2-4 mic. in diameter, spherical; cell contents pinkish or brownish **G. rosea**

Genus CŒLOSPHÆRIUM

Plate XVIII, Fig. 16

Colonies spherical, mucous, hollow, free-swimming, containing many small cells; tegument mucous, soon confluent; cells globose, elliptical or ovoid, arranged just within the periphery of the tegument; cell contents granular, with gas vacuoles; reproduction by cell division, at first in one direction, afterwards alternately in three directions.

I. Colonies 30-90 mic. in diameter; cells 2-5 mic. in diameter **C. kuetzingianum**

II. Colonies about 150 mic. in diameter; cells 5-7 mic. in diameter **C. dubium**

Genus CŒLOSPHÆRIOPSIS

Plate XVIII, Fig. 17

Colonies spherical, gelatinous, hollow; families clustered; cells spherical or elongate, arranged in a single peripheral layer; reproduction by cell division.

Colonies 30-500 mic. in diameter, spherical, gelatinous; cells 6 mic. in diameter, 6-9 mic. in length, spherical or elongate. **C. halophila**

Genus TETRAPEDIUM

Plate XVIII, Fig. 18

Cells solitary or occurring in families of from 2-16 each, compressed, quadrangular or triangular, equilateral, becoming subdivided into quadrate or wedge-shaped segments or rounded lobes, either by deep vertical or oblique incisions or by wide angular or rounded sinuses; cell contents blue-green; reproduction by cell division. (Single cells break apart by the incisions into four daughter-cells each, the daughter-cells after division forming separate individuals. The direction of the incisions is either perpendicular to the lateral margin or bisects the angles.)

Cells 3.6x7.2 mic., triangular, with conclave sides and somewhat rotund angles, elliptical in side view; cell contents homogeneous, pale blue-green. **T. trigonum**

Genus MERISMOPEDIUM

Plate XVIII, Fig. 19

Colonies flat, rectangular, free-floating; tegument somewhat thick, confluent; cells spherical, before division oblong, arranged in a rectilinear series in a single layer; cell contents usually without gas vacuoles, blue-green, rarely violet, rose-pink or red; reproduction by division of the cells in two directions.

I. Cells 5-7 mic. in diameter, 6-9 mic. in length
  1 Colonies 30 mic. in diameter; cells 5 mic. in diameter, somewhat spherical; cell contents blue-green or violet **M. ærugineum**
  2 Cells spherical or oblong **M. elegans**
  3 Cells oval **M. novum**

II. Cells 3–6 mic. in diameter
  1 Colonies 45–150 mic. in diameter; cells spherical or oval **M. glaucum**
  2 Colonies large, more or less convolute; cells spherical or oblong **M. convolutum**

III. Cells 1.3-2 mic. in diameter, somewhat spherical **M. tenuissimum**

Genus EUCAPSIS

Plate XVIII, Fig. 20

Colonies cubical, usually consisting of 32-128 cells, but ranging from 8-512 cells, free-floating; tegument uniform, colorless, gelatinous; cells spherical, sometimes elliptical or flattened by mutual pressure, forming cubical families; cell contents finely granular, blue-green; reproduction by cell division in three planes.

Colonies 30-80 mic. in diameter, usually containing 32-128 cells, free-floating; cells 6-7 mic. in diameter. **E. alpina**

Genus **ONCOBYRSA**

Plate XVIII, Fig. 21

Colonies cushion-like, hard, leathery, adherent; sheaths thick, gelatinous, confluent; cells spherical or elongated, usually regularly arranged in radial rows; cell contents blue-green or violet

I. Cells pale blue-green, sometimes violet	**O. rivularis**
II. Cells bright blue-green	**O. cesatiana**

Genus **CHLOROGLŒA**

Plate XVIII, Fig. 22

Colonies irregularly lobed; tegument thin, not lamellose; cells spherical or oval, arranged in radiating series; reproduction by cell division in one direction.

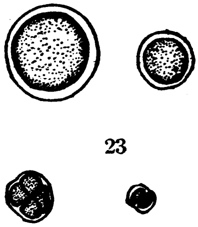
Colonies disc-shaped, epiphytic, greenish; cells 1-1.5 mic. in diameter, 2 mic. in length; ellipsoid, after division somewhat spherical.
C. tuberculosa

Family II. CHAMÆSIPHONACEÆ

Plants often showing a difference between basal and apical regions, solitary or associated in families or colonies, usually epiphytic or attached to shells; reproduction by cell division, by division of filaments into fragments, or by means of non-motile gonidia formed by the division of the contents of a mother-cell or gonidangium.

I. Reproduction by cell division and by gonidia; cells usually united in colonies
  1 Colonies somewhat spherical or hemispherical, usually consisting of several layers of cells **Pleurocapsa** **Plate XIX, Fig. 23, 24**
  2 Colonies disc-shaped, usually consisting of a single layer of cells **Xenococcus** **Fig. 25**
  3 Colonies forming branched filaments **Hyella** **Fig. 26**

II. Reproduction by gonidia only
  1 Gonidia formed by simultaneous division of the entire contents of gonidangium **Dermocarpa** **Fig. 27**
  2 Plants not usually united in colonies; gonidia formed by successive constrictions of apical portion of contents of gonidangium **Chamæsiphon** **Figs. 28, 29**



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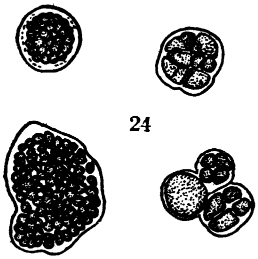

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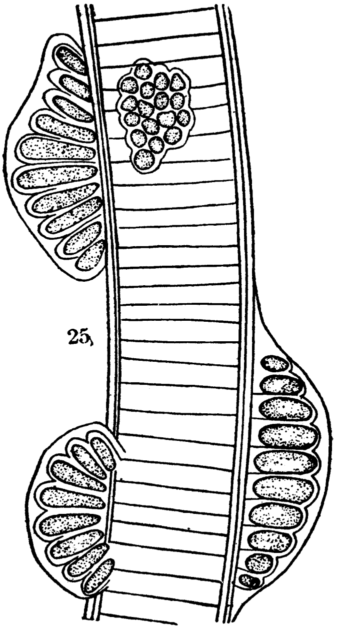

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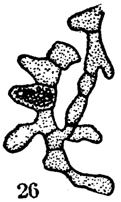

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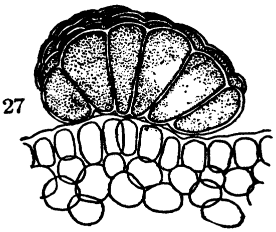

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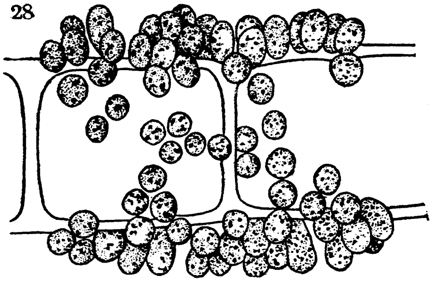

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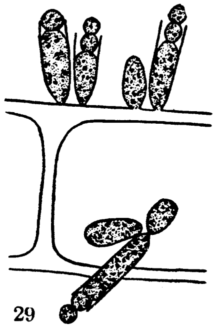

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PLATE XIX

Genus **PLEUROCAPSA**

Plate XIX, Figs. 23, 24

Colonies usually crustaceous, made up of vegetative cells and gonidangia; plants united in short filaments, parallel or scarcely distinct, radiating, often dichotomously divided; cells spherical or angular, rarely oval or polyhedral; cell contents blue-green, olive, yellowish or violet; gonidangia furnished with thick sheaths, producing numerous, spherical gonidia; reproduction by cell division in three directions, by division of filaments into fragments, and by gonidia formed by division of the contents of a gonidangium.

I. Cells arranged in straight rows; growing in fresh water **Pl. concharum**

II. Cells not arranged in straight rows
  1 Growing in hot water; cells 4-6 mic. in diameter **Pl. caldaria**
  2 Growing in salt water
    (1) Cells 5-20 mic. in diameter; cell contents golden yellow, fawn-colored or dull violet **Pl. fuliginosa**
    (2) Cells 10-13 mic. in diameter; cell contents violet **Pl. amethystea**
    (3) Cells up to 15 mic. in diameter; cell contents dull blue or slate color **Pl. crepidinum**

Genus **XENOCOCCUS**

Plate XIX, Fig. 25

Colonies disc-shaped or crustaceous, attached; cells somewhat spherical, or angular with rounded apices, crowded, forming a parenchymatous, one-celled layer, later several cells in thickness; tegument colorless or yellowish; cell contents homogeneous, blue-green or violet; reproduction by cell division in three directions or by means of gonidia developed in large peripheral cells; gonidia usually spherical, sometimes 32 developed in a gonidangium.

I. Colonies disc-shaped, composed of one layer of cells; tegument surrounding base of cells; cells 3-4 mic. in diameter, 5.5-7 mic. long, pear-shaped **X. laysanensis**

II. Colonies spherical, solitary or confluent and completely surrounding the filaments of the host; cells 4-9 mic. in diameter, spherical or flattened **X. schousbœi**

III. Colonies irregularly expanded, one or several layers in thickness; cells 4-6 mic. in diameter, 4-9 mic. in length **X. kerneri**

Genus HYELLA

Plate XIX, Fig. 26

Colonies radiately expanded, orbicular, composed of two kinds of filaments; primary filaments horizontal, tangled, twisted, finally becoming a very densely woven felty mass; secondary filaments vertical, developed from primary; branching true; tegument septate, thicker at base of filament, narrower above; cells disconnected, not joined in chains, lower ones short, sometimes divided longitudinally, upper ones longer; reproduction by means of vegetative cells set free from tegument and by means of gonidia formed in gonidangia by successive division of contents.

I. Colonies yellowish or olive, at first forming minute patches or dots, later becoming membranaceous or cushion-shaped; erect filaments usually parallel; vegetative cells usually 5-6, sometimes up to 10 mic. in diameter. **H. cæspitosa**

II. Colonies immersed in substance of shell, brownish-gray or bright blue; vegetative cells 5-10 mic. in diameter **H. fontana**

Genus DERMOCARPA

Plate XIX, Fig. 27

Colonies usually epiphytic, forming a somewhat indefinite layer; cells spherical, egg-shaped, pear-shaped, oval or oblong, solitary or united in a layer; cell contents usually blue-green or violet; reproduction by means of gonidia formed by simultaneous division of contents of the gonidangium; gonidangia oval or elongate, dissolving at apex to allow the escape of the gonidia.

I. Cells somewhat oval or oblong, not contracted at base to form a stalk
  1 Cell contents blue-green, green, olive or brown **D. prasina**
  2 Cell contents rose-colored or violet
    (1) Cells 4-5 mic. in diameter **D. rosea**
    (2) Cells 8-28 mic. in diameter **D. violacea**

II. Cells contracted at base to form a stalk
  1 Colonies dark violet-brown; cells 18-25 mic. in diameter, 40-60 mic. in length **D. fucicola**
  2 Colonies irregularly outlined; cells 8.5-11 mic. in diameter, 16.5-33.5 mic. in length **D. smaragdinus**
  3 Colonies minute; cells 9.5-17 mic. in diameter, 13-25 mic. in length **D. olivaceus**
  4 Cells 18-24 mic. in diameter, 17-24 mic. in length **D. leibleiniæ var. pelagica**

Genus CHAMÆSIPHON

Plate XIX, Figs. 28,29

Plants epiphytic, erect, cylindrical, somewhat filiform, club-shaped or pear-shaped, attached at base, widening upwards to free apex, solitary or aggregated; sheaths present; cell walls very thin; cell contents homogeneous, blue-green, violet or yellow; reproduction by one-celled, non-motile gonidia which are successively cut off from the upper portion of the contents of the gonidangium, gradually escaping from the open apex.

I. Gonidangia usually 1-2 celled	**Ch. incrustans**
II. Gonidangia many-celled	**Ch. curvatus**

Order II. HORMOGONEÆ

Plants multicellular, filamentous, attached to a substratum or free-floating; filaments simple or branched, usually consisting of one or more rows of cells within a sheath; reproduction occurs by means of hormogones or resting gonidia.

Family I. **Oscillatoriaceæ.** Filaments frequently branched, containing one or more trichomes; sheaths variable, more or less gelatinous; trichomes consisting of a simple row of cells uniform along their entire length, except for the apical cells which sometimes taper more or less; heterocysts absent; reproduction by means of vegetative division and hormogones.

Family II. **Nostocaceæ.** Sheaths very delicate, mostly confluent, usually not visible; trichomes usually twisting and entangled, consisting of a single row of uniform cells, with heterocysts; reproduction by means of vegetative division, hormogones and gonidia. Page 231.

Family III. **Scytonemaceæ.** Filaments with a false branch system; sheaths firm and tubular; trichomes consisting of a single row of cells, but not of uniform thickness, with heterocysts; reproduction by means of vegetative division, hormogones and gonidia. Page 241.

Family IV. **Stigonemaceæ.** Filaments frequently branched; sheaths thick, firm, often irregular; trichomes consisting of one or several rows of cells, with heterocysts; reproduction by means of vegetative division, hormogones and gonidia. Page 247.

Family V. **Rivulariaceæ.** Filaments tapering from the base to the apex, ending in a multicellular, colorless hair; heterocysts usually present, basal; reproduction by means of vegetative division, hormogones and gonidia. Page 251.

Family I. OSCILLATORIACEÆ

Filaments frequently branched, containing one or more trichomes; sheaths variable, more or less gelatinous; trichomes consisting of a simple

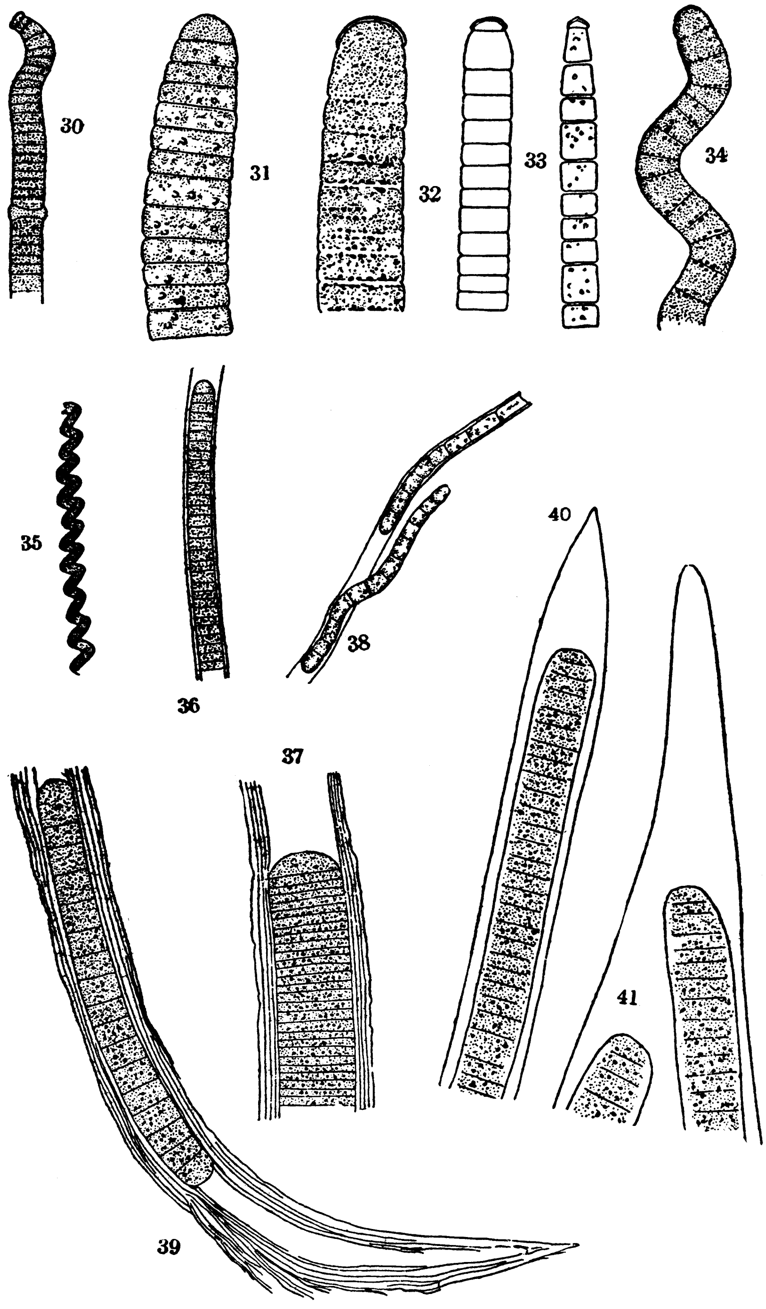

Plate XX

row of cells uniform along their entire length; except for the apical cells which sometimes taper more or less; heterocysts absent; reproduction by means of vegetative division and hormogones.

I. Sheaths not present
1 Trichomes straight or nearly so, never forming a regular spiral
(1) Trichomes cylindrical, usually without sheaths, free; apex of trichome straight or curved **Oscillatoria**
Plate XX, Figs. 30, 31, 32
(2) Trichomes cylindrical, without sheaths, united in free-swimming scale-like masses **Trichodesmium**
Fig. 33
2 Trichomes forming a regular, more or less lax spiral
(1) Trichomes multicellular **Arthrospira**
Fig. 34
(2) Trichomes unicellular **Spirulina**
Fig. 35
II. Sheaths present
1 Filaments simple or branched; sheaths cylindrical, firm; trichomes single within the sheath; apex of trichome straight
(1) Filaments simple, more or less agglutinated by their mucous sheaths **Phormidium**
Fig. 36
(2) Filaments simple, free, free-floating or forming a matted mass **Lyngbya**
Fig. 37
(3) Filaments often branched, forming erect tufts; false branches solitary **Symploca**
Fig. 38
(4) Filaments simple; sheaths usually purple or flesh-colored; apical cell not capitate **Porphyrosiphon**
Fig. 39
2 Filaments frequently branched; sheaths firm, lamellose, transparent or colored; trichomes several within the sheath
(1) Sheaths more or less mucous, colorless, diffluent; trichomes few within the sheath; apex of trichome capitate **Hydrocoleus**
Figs. 40, 41
(2) Filaments prostrate, woven into a solid membranaceous mass, often slightly branched; sheaths solid, always thin, colorless; plants terrestrial or aquatic **Hypheothrix**
Plate XXI, Fig. 42
(3) Filaments prostrate at the base, above forming erect tufts; sheaths solid, transparent; plants terrestrial **Symplocastrum**
Figs, 43, 44, 45

(4) Filaments tufted, often much branched; sheaths transparent or scarcely colored; plants low, aquatic **Inactis**
Fig. 46

(5) Filaments branched; sheaths solid, closed at the apex, of various colors; trichomes densely aggregated within the sheath **Schizothrix**
Fig. 47

(6) Sheaths wide, transparent or yellowish brown; trichomes very few within the sheath, very loosely aggregated **Dasyglœa**
Fig. 48

(7) Sheaths mucous, not lamellose, always transparent; trichomes many within the sheath **Microcoleus**
Fig. 49

3 Colonies somewhat spherical, elliptical or spindle-shaped; filaments solitary or aggregated in colonies; sheaths thick, gelatinous

(1) Sheaths very thick; trichomes usually single or in scattered fragments **Catagnymene**
Fig. 50

(2) Colonies somewhat spherical; sheaths thick; trichomes curved, radiating **Haliarachne**

Genus OSCILLATORIA

Plate XX, Figs. 30, 31, 32

Trichomes cylindrical, free, motile, without a sheath or rarely enclosed in a very thin, fragile, mucous sheath, often constricted at the joints; apex of trichome straight, curved, or more or less regularly spiralled, often tapering; outer wall of apical cell often thickened, forming a calyptra.

I. Plants living in fresh water, floating; apex of trichome constantly straight, gradually tapering, obtuse, finally capitate; cells somewhat quadrate or shorter than the diameter, never very short

1 Plant mass purple; trichomes 2.2-5 mic. in diameter; cells somewhat quadrate or longer than the diameter **O. prolifica**

2 Plant mass light blue-green; trichomes 4-6 mic. in diameter; cells somewhat quadrate or twice as short as the diameter **O. agardhii**

II. Plants living in fresh water, sometimes in hot water; trichomes large or very large; apex of trichome straight, curved or spiral, not at all or briefly tapering, obtuse; cells very short

1 Transverse walls never granulated
  - (1) Trichomes 16-60 mic. in diameter; apex of trichome slightly tapering, somewhat capitate, hooked **O. princeps**
  - (2) Trichomes 12-15 mic. in diameter; apex of trichome tapering, capitate, hooked or loosely terebriform **O. proboscidea**

2 Transverse walls frequently granulated
  - (1) Apex of trichome straight
    - A Trichomes 10-20 mic. in diameter, constricted at joints; apex of trichome very briefly tapering, somewhat capitate **O. sancta**
    - B Trichomes 11-20 mic. in diameter, not constricted at joints; apex of trichome neither tapering nor capitate **O. limosa**
  - (2) Apex of trichome spiral, rarely hooked
    - A Trichomes 10-17 mic. in diameter, not constricted at joints; apex of trichome not capitate **O. curviceps**
    - B Trichomes 18-23 mic. in diameter; apex of trichome slightly tapering, obtusely rounded, usually straight **O. major**
    - C Trichomes 9-11 mic. in diameter, slightly constricted at joints, here and there interrupted by inflated, refringent cells; apical cell not capitate **O. ornata**
    - D Trichomes 6-8 mic. in diameter, not constricted at joints, here and there interrupted by inflated, refringent cells; apical cell capitate **O. anguina**

III. Plants living in salt water; trichomes always constricted at joints, rarely straight or spiral throughout; apex of trichome scarcely tapering, very gradually curved, obtuse

1 Trichomes twisted into a regular spiral **O. bonnemaisonii**

2 Trichomes not spiral, gradually curved in apical portion, rarely straight
  - (1) Plant mass dull red; trichomes 16-24 mic. in diameter **O. miniata**
  - (2) Plant mass olive green; trichomes 17-29 mic. in diameter **O. margaritifera**
  - (3) Plant mass dark olive green; trichomes 7-11 mic. in diameter, straight, fragile **O. nigro-viridis**
  - (4) Plant mass thin, fragile; trichomes 9.6-11.9 mic. in diameter, sometimes spirally coiled, sometimes curved or even nearly straight **O. capitata**

(5) Plants epiphytic; trichomes 6-10 mic. in diameter, flexuous, flexible **O. corallinæ**

IV. Plants living in fresh water, sometimes in hot water; trichomes straight or curved, not tapering at the apices

1 Trichomes 8.5 mic. in diameter, straight or slightly flexuous **O. nigra**

2 Trichomes 4-10 mic. in diameter, usually slightly constricted at the joints, often curved at the apices; transverse walls usually furnished with two rows of granules **O. tenuis**

3 Trichomes 2-3 mic. in diameter, not constricted at joints, curved at the apices; transverse walls commonly marked by two protoplasmic granules **O. amphibia**

4 Trichomes 1-1.5 mic. in diameter, straight or rolled in a circinate manner **O. subtilissima**

5 Trichomes 2.3-4 mic. in diameter, curved, very much constricted at joints; transverse walls pellucid, not granulated **O. geminata**

6 Trichomes 2.5 mic. in diameter, especially constricted at joints; transverse walls pellucid **O. minnesotensis**

7 Trichomes 3.5-4 mic. in diameter, not constricted at joints; transverse walls pellucid, not granulated **O. chlorina**

8 Trichomes .6 mic. in diameter, flexible, elongate, tangled, not constricted at joints **O. angustissima**

V. Plants living in fresh water, hot water, rarely in salt water; trichomes tapering, more or less pointed, hooked or flexuous, not entirely spiralled (except O. chalybea); cells longer or shorter than the diameter, never very short

1 Apical cell capitate

(1) Trichomes 2-3 mic. in diameter; cells longer than their diameter **O. splendida**

(2) Trichomes 2.5-5 mic. in diameter; cells somewhat quadrate **O. amœna**

2 Apical cell not capitate

(1) Plants living in salt water

A Trichomes 4.7-6.5 mic. in diameter, flexible, undulating; apex of trichome very gradually tapering, very flexuous **O. subuliformis**

B Trichomes 4 mic. in diameter, somewhat flexuous, sometimes coiled in a regular circle, very much constricted at joints; apex of trichome tapering, slightly curved, obtuse **O. salinarum**

C Trichomes 3-5 mic. in diameter, fragile, straight; apex of trichome briefly tapering, hooked or undulating
O. læte-virens

(2) Plants living in fresh water, often in hot water, rarely in brackish water

A Trichomes 3-5 mic. in diameter; apex of trichome briefly tapering, very sharply pointed, hooked; cells usually longer than their diameter **O. acuminata**

B Trichomes 3-4 mic. in diameter; apex of trichome briefly tapering, very sharply pointed, hooked; cells usually shorter than their diameter **O. animalis**

C Trichomes 4-4.5 mic. in diameter, straight, entangled; transverse walls granulated; cell contents violet or sky-blue
O. violacea

D Trichomes 4-6.5 mic. in diameter, here and there interrupted by inflated refringent cells; apex of trichome briefly tapering, hooked or flexuous; cells three times shorter than their diameter **O. brevis**

E Trichomes 4-7 mic. in diameter; apex of trichome obtuse, straight, rarely slightly curved **O. cruenta**

F Trichomes 4-6 mic. in diameter, slightly constricted at joints; apex of trichome briefly and somewhat obtusely tapering, hooked; cells quadrate or one-half as long as wide
O. formosa

G Trichomes 2.5-4 mic. in diameter, constricted at joints; apex of trichome very gradually tapering, hooked or undulating; cells quadrate or longer than the diameter
O. numidica

H Trichomes 5.5-8 mic. in diameter, slightly constricted at joints; apex of trichome very gradually tapering, hooked or undulating; cells quadrate or longer than the diameter, very long near the apex **O. cortiana**

I Trichomes 5.5-9 mic. in diameter, constricted at joints; apex of trichome very gradually tapering, undulating and finally hooked; apical cell obtuse; cells shorter than their diameter
O. okeni

J Trichomes 8-13 mic. in diameter, scarcely constricted at joints, sometimes twisted in loose spirals; apex of trichome briefly or gradually tapering and hooked; apical cell obtuse; cells shorter than their diameter
O. chalybea

K Trichomes 8-10 mic. in diameter, straight, somewhat constricted at joints; apex of trichome often slightly tapering, obtuse, straight or curved **O. subsalsa**

L Trichomes 15.5-18.5 mic. in diameter, straight; apex of trichome usually curved, somewhat tapering, obtuse-truncate **O. percursa**

VI. Plants living in fresh water, sometimes in hot water; trichomes regularly terebriform in apical portion or forming a spiral throughout their entire length, more or less tapering in the apical portion

1 Trichomes 6-8 mic. in diameter, forming a lax and regular spiral through their entire length, or straight and hooked at the apex; apical cell pointed, not capitate **O. boryana**

2 Trichomes 4-6.5 mic. in diameter, flexuous, straight below, loosely spiralled and terebriform above; apical cell obtuse, not capitate **O. terebriformis**

Genus **TRICHODESMIUM**

Plate XX, Fig. 33

Plants forming scale-like, disconnected, free-floating colonies quickly dissolving into mucous; trichomes cylindrical, without sheaths; apex of trichome straight, tapering, slightly capitate; apical cell truncate-conical, furnished with a convex calyptra.

Floating in great abundance in the ocean, especially in equatorial regions.

I. Trichomes straight **T. erythræum**

II. Trichomes flexuous or spirally twisted

1 Colonies up to 6 mm. in length; trichomes 7-16 mic. in diameter, not constricted at joints, those in center of colony having the form of twisted ropes, free at the ends **T. thiebautii**

2 Colonies spirally twisted, light yellow; trichomes 16-25 mic. in diameter, twisted together into cords **T. contortum**

Genus **ARTHROSPIRA**

Plate XX, Fig. 34

Trichomes multicellular, cylindrical, without a sheath, forming a very regular, more or less loose spiral; apex of trichome sometimes tapering; apical cell rotund; calyptra none.

I. Trichomes 5-8 mic. in diameter, forming a loose spiral 9-15 mic. in diameter, the distance between the turns being 21-31 mic. **A. jenneri**

II. Trichomes 2.5-3 mic. in diameter, forming a rather loose spiral about 6 mic. in diameter, the distance between the turns being 16-18 mic. **A. gomontiana**

Genus **SPIRULINA**

Plate XX, Fig. 35

Trichomes unicellular, cylindrical, without a sheath, forming a regular, more or less loose or close spiral; apex of trichome not tapering; cell contents homogeneous or slightly granular.

I. Turns of the spiral not close together
  1 Trichomes 1.2-1.8 mic. in diameter, forming a more or less loose, somewhat irregular spiral 3.2-5 mic. in diameter, the distance between the turns being 3-5 mic. **S. meneghiniana**
  2 Trichomes 1.2-1.7 mic. in diameter, forming a somewhat loose, regular spiral 2.5-4 mic. in diameter, the distance between the turns being 2.7-5 mic. **S. major**
  3 Trichomes 2 mic. in diameter, forming an especially regular spiral 5 mic. in diameter, the distance between the turns being 5 mic. **S. nordstedtii**
  4 Trichomes .6-.9 mic. in diameter, forming an especially regular spiral 1.5-2.5 mic. in diameter, the distance between the turns being 1.2-2 mic. **S. subtilissima**
  5 Trichomes .4 mic. in diameter, forming an especially regular spiral 1.4-1.6 mic. in diameter, the distance between the turns being 1 mic. **S. tenerrima**
  6 Trichomes .9 mic. in diameter, forming a very loose spiral 1.5 mic. in diameter, the distance between the turns being 3.2 mic. **S. caldaria**

II. Turns of the spiral close together
  1 Trichomes 1.2-1.8 mic. in diameter, forming a dense regular spiral 3-4.5 mic. in diameter, the turns being contiguous **S. versicolor**
  2 Trichomes 1-2 mic. in diameter, forming a somewhat irregular dense or rarely regular spiral 3-5 mic. in diameter, the turns being contiguous or nearly so **S. subsalsa**

III. Trichomes forming slender, flat, continuous bands (when untwisted forming a complete ring), normally flattened and twisted, with one to four or more turns **S. duplex**

Genus **PHORMIDIUM**

Plate XX, Fig. 36

Filaments simple, forming a woolly or felt-like layer or rarely floating, attached at the base with free ends torn and ragged; sheaths thin, transparent, mucous, agglutinated, partly or entirely diffluent; trichomes cylindrical, in some species constricted at joints, never distinctly spiral; apex of trichome often tapering, straight or curved, capitate or not capitate; outer membrane of apical cell thickened into a calyptra in many species.

I. Trichomes especially constricted at joints, even moniliform; apex of trichome neither curved nor capitate
  1 Trichomes scarcely 4 mic. in diameter
    (1) Plants living in hot or in brackish water; trichomes 1.2-2.3 mic. in diameter; cells somewhat quadrate **P. fragile**
    (2) Plants living in salt water; plant mass rose-colored; trichomes 1.7-2 mic. in diameter; cells longer than the diameter **P. persicinum**
    (3) Plants terrestrial, nestling in pits in rocks; trichomes 1.5 mic. in diameter; cells somewhat quadrate **P. foveolarum**
  2 Trichomes 6-8.5 mic. in diameter **P. tinctorium**

II. Trichomes rarely or scarcely constricted at joints; apex of trichome straight or curved, capitate in many species
  1 Trichomes scarcely 3 mic. in diameter
    (1) Plant mass purplish violet, reddish brown or scarlet
      A Filaments somewhat straight; trichomes slightly constricted at joints; transverse walls not granulated **P. luridum**
      B Filaments somewhat straight; trichomes fragile, frequently interrupted, not constricted at joints; transverse walls rarely visible **P. rubrum**
      C Filaments very much twisted; trichomes not constricted at joints; transverse walls marked by four protoplasmic granules **P. purpurascens**
      D Filaments curved, entangled or arranged parallel with each other, trichomes not constricted at joints; apex of trichome straight, neither tapering nor capitate **P. crosbyanum**
    (2) Plant mass blue-green or olive
      A Plants living in hot water; plant mass expanded, lamellose, composed of many superposed papery layers; trichomes .6-.8 mic. in diameter, not constricted at joints; apex of trichome straight, not tapering **P. treleasei**
      B Plant mass thin, membranaceous; trichomes 1-1.5 mic. in diameter, not constricted at joints; apex of trichome straight, tapering; transverse walls granulated **P. laminosum**

C Plant mass thin, membranaceous; trichomes 1-2 mic. in diameter, slightly constricted at joints; apex of trichome finally becoming tapered and bent; transverse walls not granulated **P. tenue**

D Plant mass thick, leathery; trichomes 2-2.5 mic. in diameter, not constricted at joints; apex of trichome straight, obtuse **P. valderianum**

E Plant mass lamellose; trichomes 2-2.8 mic. in diameter, slightly constricted at joints; apex of trichome gradually tapering, bent or twisted **P. subuliforme**

2 Trichomes more than 3 mic. in diameter
  (1) Apex of trichome straight, not capitate
    A Apical cell obtuse conical
      a Plant mass encrusted with calcium carbonate **P. incrustatum**

      b Plant mass not encrusted with calcium carbonate
        (a) Filaments somewhat straight; trichomes 3-5 mic. in diameter; transverse walls covered by protoplasmic granules **P. inundatum**

        (b) Filaments flexuous; trichomes 3-4.5 mic. in diameter; cells 3.4-8 mic. in length; transverse walls conspicuous **P. corium**

        (c) Filaments strongly flexuous; trichomes 3-5 mic. in diameter; cells 2-4 mic. in length; transverse walls conspicuous **P. papyraceum**

        (d) Plant mass membranaceous, mucous; trichomes 5-6.5 mic. in diameter, interrupted; apex of trichome straight, obtuse; transverse walls sometimes finely granulated **P. interruptum**

        (e) Plant mass thin; trichomes 16-18 mic. in diameter, frequently interrupted **P. naveanum**

    B Apical cell not or scarcely tapering, truncate
      a Sheaths thin, fragile, soon diffluent; trichomes 4.5-12 mic. in diameter; cells 4-9 mic. in length **P. retzii**
      b Sheaths firm, or mucous and diffluent, at times thick and lamellose; trichomes 4-6 mic. in diameter; cells 1.5-2.7 mic. in length **P. ambiguum**

  (2) Apex of trichome straight, capitate
    A Trichomes slightly constricted at joints **P. submembranaceum**

B Trichomes not constricted at joints
  a Plants epiphytic, living in salt water; trichomes 4-4.5 mic. in diameter, irregularly curved, very rarely straight; apex of trichome gradually tapering; cells 4-11 mic. in length **P. laysanense**

  b Plants living in warm or fresh water; trichomes 4.5-9 mic. in diameter, elongate, flexuous; apex of trichome gradually tapering; cells 3-7 mic. in length **P. favosum**

  c Plants living in warm or fresh water; trichomes 6-8 mic. in diameter, apex of trichome scarcely tapering; apical cell oblique, depressed, conical **P. calidum**

  d Plants living in fresh water; trichomes 5.5-11 mic. in diameter, straight, fragile; apex of trichome briefly tapering; apical cell straight, conical; cells 2-4 mic. in length **P. subfuscum**

(3) Apex of trichome more or less curved, capitate
 A Plant mass blue-green or dark brown
  a Plants living in fresh water; trichomes 6-9 mic. in diameter; apex of trichome curved or briefly spiraled **P. uncinatum**

  b Plants living on damp soil or on rocks, rarely under water; trichomes 4-7 mic. in diameter; apex of trichome scarcely curved, sometimes straight **P. autumnale**

 B Plant mass dark purple **P. setchellianum**

Genus **LYNGBYA**

Plate XX, Fig. 37

Filaments free, unbranched, free-floating or forming a densely intricate floccose or expanded mass; sheaths firm, of variable thickness, sometimes lamellose, colorless or rarely yellowish brown; trichomes sometimes constricted at the joints, either obtuse or slightly tapering at the apices; outer wall of apical cell sometimes thickened forming a calyptra.

I. Trichomes not more than 2 mic. in diameter
 1 Plants living in salt water, epiphytic; transverse walls marked by two refringent granules
  (1) Filaments 1.5 mic. in diameter, trichomes .5 mic. in diameter, cylindrical, not constricted at joints; cells 1.5 mic. in length **L. mucicola**

  (2) Filaments 1.5-2 mic. in diameter; sheaths very thin, scarcely visible; cells 2-7 mic. in length **L. perelegans**

2 Plants living in fresh water
  (1) Sheaths thin, colorless
    A Filaments coiled or spiraled
      a Filaments coiled; trichomes .8 mic. in diameter, constricted at joints; cells 2.3-3.2 mic. in length **L. rivulariarum**

      b Filaments more or less regularly spiraled, sometimes straight; trichomes 2 mic. in diameter; cells 1.2-3 mic. in length **L. lagerheimii**

    B Filaments straight or curved
      a Filaments 1.9 mic. in diameter; apex of trichome bluntly rounded; cells quadrate or a little longer than diameter **L. nana**

      b Filaments solitary and scattered; trichomes 1.5-1.8 mic. in diameter, somewhat flexuous; cells up to 3.6 mic. in length **L. subtilis**

      c Filaments 1.8 mic. in diameter, at first attached, afterwards free, short, straight or slightly curved; cells about equal in length to the diameter **L. distincta**

  (2) Sheaths more or less thick and gelatinous
    A Plant mass ochre-yellow in color; sheaths at first thin, colorless, later thick and yellowish; trichomes .9 mic. in diameter, especially constricted at joints, frequently interrupted **L. ochracea**

    B Plant mass rust-colored; sheaths at first thin, colorless, later thicker and rust-colored; trichomes .8-.9 mic. in diameter, not constricted at joints, continuous **L. ferruginea**

II. Trichomes 2-6 mic. in diameter; sheaths usually thin and colorless, sometimes becoming thick and yellowish
  1 Plants living in salt water, sometimes in brackish, fresh or hot water
    (1) Filaments coiled, densely entangled; sheaths thin, colorless, later becoming thick and lamellose; trichomes 2.5-6 mic. in diameter, not constricted at joints; cells 1.5-5.5 mic. in length **L. lutea**

    (2) Plants living in salt water, epiphytic; sheaths thin, delicate; trichomes 3-4.5 mic. in diameter, constricted at joints; cells up to 13 mic. in length **L. holdenii**

2 Plants living in fresh water; sheaths usually thin and colorless

(1) Plant mass cæspitose, light green; trichomes 2-3 mic. in diameter, not constricted at joints; cells 1-3.7 mic. in length **L. digueti**

(2) Plant mass cæspitose, blue-green; sheaths delicate, smooth, usually inconspicuous; trichomes 3.2-3.5 mic. in diameter, somewhat rigid, forming tufts **L. penicillata**

(3) Plant mass dull blue-green; trichomes 4-6 mic. in diameter, not constricted at joints; cells 2.3-3 mic. in length **L. ærugineo-cærulea**

(4) Plants epiphytic; filaments straight or sharply curved and twisted; trichomes 5-6 mic. in diameter, not constricted at joints **L. cladophoræ**

(5) Plant mass at first adherent, afterwards free, rust-colored on the outside, olive green within; sheaths colorless, sometimes yellowish, slightly mucous and agglutinated, thick; trichomes 2.8-3.2 mic. in diameter, not constricted at joints; cells 2-6.4 mic. in length **L. versicolor**

III. Trichomes 5-60 mic. in diameter

1 Plants living in salt water, epiphytic; plant mass cæspitose

(1) Plant mass purplish-violet; trichomes 5-8 mic. in diameter; constricted at joints; cells 2.8-4.6 mic. in length; cell contents rose-colored **L. gracilis**

(2) Plant mass dull blue-green; trichomes 6.5-8 mic. in diameter, constricted at joints; cells 2-4 mic. in length; cell contents pale blue-green **L. meneghiniana**

(3) Plant mass dark or dull yellowish green; trichomes 14-31 mic. in diameter, evidently constricted at joints; cells 4-10 mic. in length; cell contents frequently showing scattered coarse granules, olive green **L. sordida**

2 Plants living in salt water; plant mass cæspitose, extended, mucous, dull yellowish or dark green, when dried becoming dark violet; sheaths thick

(1) Trichomes 5-12 mic. in diameter; apex of trichome slightly tapering, capitate; cells 2-3 mic. in length **L. semiplena**

(2) Trichomes 9-25 mic. in diameter; apex of trichome not tapering, not capitate; cells 2-4 mic. in length **L. confervoides**

3 Plants living in salt, brackish, fresh or warm water or on moist earth
  (1) Trichomes 8-24 mic. in diameter; apex of trichome slightly tapering, capitate; apical cell truncate, rarely somewhat acute-conical; cells 2.7-5.6 mic. in length **L. æstuarii**
  (2) Trichomes 16-60 mic. in diameter; apex of trichome not tapering, not capitate; apical cell rotund; cells 2-4 mic. in length **L. majuscula**

4 Plants living in fresh water, often in hot or warm water
  (1) Plant mass cæspitose, dull or dark green or blue-green
    A Sheaths thickened and roughened with age; trichomes 6-10 mic. in diameter, not constricted at joints; apex of trichome not tapering, not capitate; cells 1.7-3.3 mic. in length **L. martensiana**
    B Sheaths colorless, thin, papery; trichomes 7.5-13 mic. in diameter, especially constricted at joints; apex of trichome not tapering, not capitate; cells 3-10 mic. in length **L. putealis**
    C Sheaths colorless, thick, roughened; trichomes 11-16 mic. in diameter, not constricted at joints; apex of trichome slightly tapering, somewhat capitate; cells 2-3.4 mic. in length **L. major**
  (2) Plant mass floating, olive green; filaments forming a regular loose spiral throughout the whole or a portion of their length; trichomes 14-16 mic. in diameter, not constricted at joints; cells 3.4-6.8 mic. in length **L. spirulinoides**
  (3) Plant mass formed of loosely entangled filaments, dark green; filaments 15-19 mic. in diameter; trichomes 12.5 mic. in diameter; cells very short **L. arachnoidea**

Genus SYMPLOCA

Plate XX, Fig. 38

Filaments branched, ascending from a prostrate base, agglutinated together in erect or anastomosing fascicles, or wick-like bundles, more or less procumbent, coalescing; false branches solitary; sheaths thin, colorless, firm or somewhat mucous; apex of trichome straight, sometimes a little tapering; outer membrane of apical cell slightly thickened in some species.

I. Plants living in salt water
  1 Fascicles erect
    (1) Plant mass blackish green; trichomes 4-6 mic. in diameter, constricted at joints throughout entire length **S. atlantica**

(2) Plant mass dull or dark lead-colored; trichomes 6-14 mic. in diameter, constricted at joints near apices **S. hydnoides**

2 Fascicles appressed; trichomes 1.5-3.5 mic. in diameter, especially constricted at joints **S. læte-viridis**

II. Plants living on moist earth, or in fresh or hot water
1 Trichomes 1-3 mic. in diameter
(1) Plant mass blackish green; trichomes 4.6 mic. in diameter, sometimes constricted at joints **S. thermalis**

(2) Plant mass compact, fibrous; trichomes 1.5-2.5 mic. in diameter, not constricted at joints **S. dubia**

(3) Plant mass blue-green, changing to brown; trichomes 2-3 mic. in diameter **S. fuscescens**

2 Trichomes 3-8 mic. in diameter
(1) Fascicles short, erect, spine-shaped; trichomes 3.4-4 mic. in diameter, not constricted at joints; cells somewhat quadrate or shorter than the diameter **S. muralis**

(2) Fascicles tapering from a broad base to a loose, somewhat penicillate apex; trichomes 5.6 mic. in diameter; cells a little longer than their diameter, after division shorter **S. borealis**

(3) Fascicles elongate, usually procumbent, spine-shaped; trichomes 5-8 mic. in diameter, not constricted at joints; cells somewhat quadrate or longer than the diameter **S. muscorum**

Genus **POROHYROSIPHON**

Plate XX, Fig. 39

Filaments unbranched; sheaths firm, solid, lamellose, usually purple or flesh-colored; trichomes solitary within the sheath; apical cell not capitate.

Plant mass expanded, cushion-shaped, dark purple; sheaths firm, finally becoming very thick, lamellose, with the apex tapering and fibrillose; trichomes 8-19 mic. in diameter; cells 4.5-12 mic. in length **P. notarisii**

Genus **HYDROCOLEUS**

Plate XX, Figs. 40, 41

Plant mass forming a cæspitose cushion, very rarely hardened with calcium carbonate, or cæspitose but somewhat indefinite, or even not at all cæspitose, but Phormidium-like; sheaths always colorless, cylindrical, somewhat lamellose, more or less mucous or somewhat amorphous, later entirely diffluent; trichomes few within the sheath, often loosely aggregated; apex of trichome straight, more or less tapering, capitate; outer membrane of apical cell thickened into a calyptra; cells shorter than the diameter of the trichome, in some species very short.

I. Plants living in salt water
  1 Plant mass cæspitose
    (1) Plant mass green becoming violet; sheaths cylindrical, moderately mucous; trichomes 14-21 mic. in diameter **H. comoides**
    (2) Plant mass blackish green; sheaths irregular in outline, strongly mucous; trichomes 18-24 mic. in diameter **H. cantharidosmus**
  2 Plant mass cæspitose or forming an expanded mucous stratum, blackish green; sheaths irregular in outline, strongly mucous or even entirely diffluent; trichomes 8-16 mic. in diameter **H. lyngbyaceus**
  3 Plant mass mucous
    (1) Plant mass yellowish brown or dull green; sheaths somewhat amorphous or entirely diffluent; trichomes 14-21 mic. in diameter **H. glutinosus**
    (2) Plant mass pale blue-green; sheaths agglutinated, forming a diffluent, amorphous layer; trichomes 25-30 mic. in diameter **H. holdenii**
II. Plants living in fresh water
  1 Trichomes 6-8 mic. in diameter; apex of trichome gradually tapering, evidently capitate; cells somewhat quadrate or one-half the diameter of the trichome in length **H. homœotrichus**
  2 Trichomes 12 mic. in diameter; cells quadrate or two or three times shorter than the diameter **H. ravenelii**
  3 Trichomes 16-19 mic. in diameter; apex of trichome somewhat tapering, scarcely capitate; cells 2-5 times shorter than the diameter **H. heterotrichus**

Genus HYPHEOTHRIX

Plate XXI, Fig. 42

Plants living on moist earth or dripping rocks; filaments prostrate, commonly slightly branched, woven into a more or less compact mass; sometimes hardened with calcium carbonate; sheaths always colorless.

I. Filaments very much twisted, scarcely flexible, ruptured if disentangled

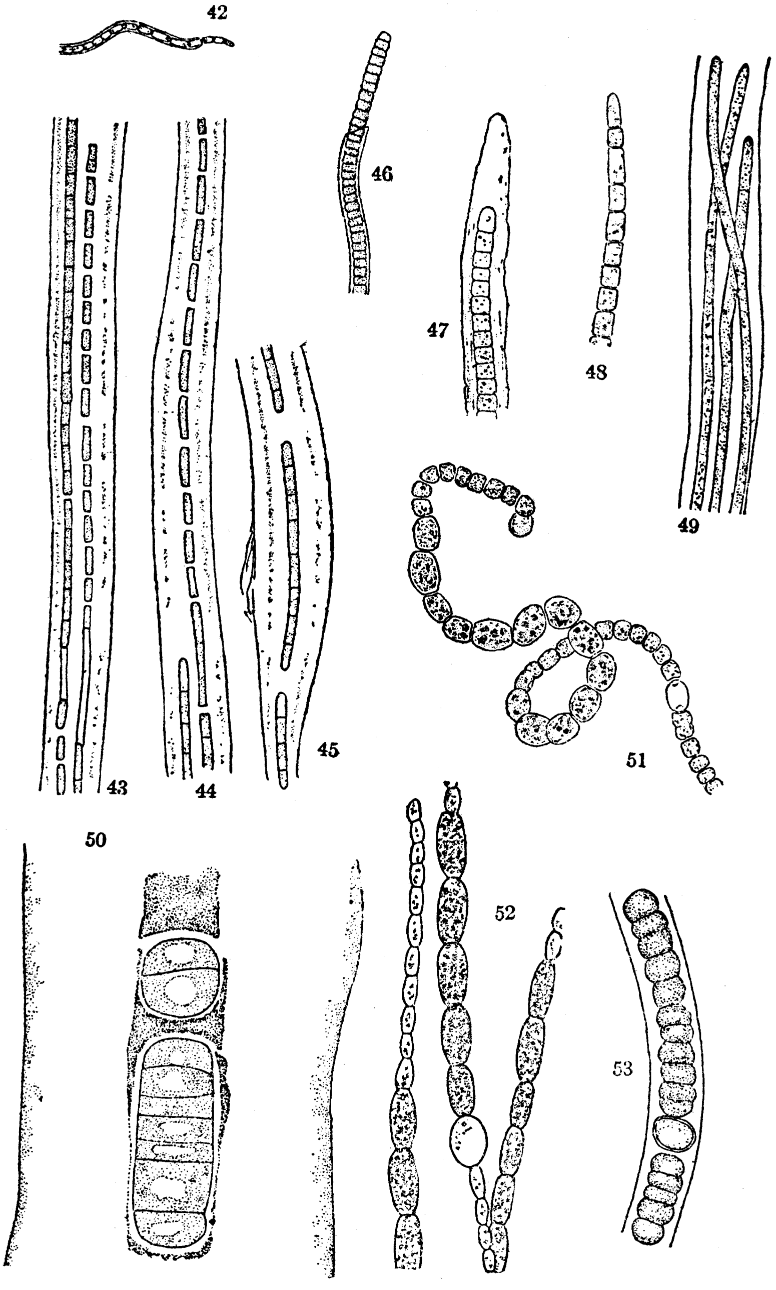

Plate XXI

1 Plant mass thin, somewhat gelatinous, papery-membranaceous, very hard when dry, not encrusted with calcium carbonate; sheaths firm; trichomes 1-1.7 mic. in diameter, usually one or two within the sheath **H. calcicola**

2 Plant mass flocculent, waving, light fawn-colored; filaments 1.2-1.8 mic. in diameter; sheaths inconspicuous; transverse walls not visible **H. hinnulea**

3 Plant mass forming a small mat; filaments 1.5-2 mic. in diameter; sheaths closely adherent, entirely diffluent **H. glœophila**

4 Plant mass thin, cushion-shaped, mucous; filaments 1.8-2.2 mic. in diameter; sheaths close **H. herbacea**

5 Plant mass sometimes expanded, forming loosely interwoven masses or small cushion-shaped clusters; filaments 3.5-4 mic. in diameter; sheaths firm, close **H. tenax**

6 Plant mass somewhat spherical, hollow, tough, yellowish or light straw-colored; filaments 4-6 mic. in diameter; trichomes 1.5-2 mic. in diameter **H. bullosa**

7 Plant mass compact, leathery, brick-colored; filaments up to 7.5 mic. in diameter; sheaths wide, membranaceous, firm, homogeneous, smooth; trichomes 3.2-4 mic. in diameter, here and there interrupted **H. turicensis**

8 Plant mass more or less expanded, olive green; filaments 8-11 mic. in diameter; sheaths moderately wide; trichomes 3.5 mic. in diameter, here and there interrupted, often constricted at joints **H. aikensis**

II. Filaments long and flexible, disentangled without rupturing

1 Plant mass encrusted with calcium carbonate; trichomes 1-1.7 mic. in diameter; cells longer than the diameter **H. coriacea**

2 Plant mass not encrusted with calcium carbonate; trichomes 1.5-2 mic. in diameter; cells longer than the diameter **H. lardacea**

3 Plant mass not encrusted with calcium carbonate; trichomes 1.5-3 mic. in diameter; cells longer than the diameter **H. arenaria**

4 Plant mass compact, leathery, roughened; trichomes 2.3-2.8 mic. in diameter; cells a little shorter than the diameter **H. vulpina**

5 Plant mass membranaceous, firm, smooth, pale rose or dark red; trichomes 5.6-8.3 mic. in diameter; cells somewhat quadrate **H. pallida**

Genus SYMPLOCASTRUM

Plate XXI, Fig. 43, 44, 45

Plants terrestrial or living on damp rocks; filaments twisted and entangled, ascending from a prostrate base, agglutinated together in erect fascicles; sheaths colorless.

I. Plant mass blue-green; trichomes 1.4-2 mic. in diameter, constricted at the joints; cells shorter than the diameter **S. fragile**

II. Plant mass flesh-colored or reddish; trichomes 1.6-2 mic. in diameter; cells usually longer than the diameter **S. rubrum**

III. Plant mass gray or yellowish; trichomes 1.9-2.3 mic. in diameter; cells longer than the diameter **S. cuspidatum**

IV. Plant mass blackish, olive or lead-colored; trichomes 3-6 mic. in diameter; cells somewhat quadrate or longer than the diameter **S. friesii**

Genus INACTIS

Plate XXI, Fig. 46

Plants growing in moist places or in rivers; filaments cæspitose, often with numerous false branches, forming cushions which finally often become encrusted with calcium carbonate and hardened, zonate within, or aggregated into penicillate, floating fascicles; sheaths colorless or nearly so.

I. Plant mass cushion-shaped, tufted

1 Plant mass strongly encrusted with calcium carbonate, stony; filaments straight, somewhat simple; trichomes 1-2 mic. in diameter; cells somewhat quadrate **I. pulvinata**

2 Plant mass strongly encrusted with calcium carbonate, stony; filaments slender, simple in basal portions, fasciculately branched above; trichomes 1.4-3 mic. in diameter; cells somewhat quadrate or longer than the diameter **I. fasciculata**

3 Plant mass cushion-shaped or crustaceous, not hardened with calcium carbonate; filaments forming trunk at base, very much branched in upper portions; trichomes 1-1.5 mic. in diameter; cells longer than the diameter **I. lacustris**

4 Plant mass somewhat hemispherical, plano-convex; filaments more or less branched, growing in tufts; cells two or three times longer than broad **I. austini**

II. Plant mass forming penicillate fascicles, floating
  1 Plant mass submerged, attached; filaments very long; trichomes 1.4-2.4 mic. in diameter, constricted at joints **I. tinctoria**
  2 Plant mass submerged, epiphytic on other algæ; trichomes 3-6 mic. in diameter, usually constricted at joints **I. simmonsiæ**
  3 Plant mass submerged, attached; filaments very long; trichomes 6 mic. in diameter, constricted at joints **I. mexicana**

III. Filaments solitary, growing in gelatinous mass formed by other algæ; trichomes 1.5-2 mic. in diameter, not constricted at joints **I. hawaiensis**

Genus SCHIZOTHRIX

Plate XXI, Fig. 47

Plants living on moist earth or in water, or in inundated places, rarely entirely aquatic; filaments forming erect or prostrate, Symploca-like fascicles or a pannose stratum, rarely floating free; sheaths in the beginning colorless, finally becoming yellowish brown, purplish pink or bluish.

I. Cells somewhat quadrate or shorter than the diameter
  1 Plant mass thin, encrusted, often widely expanded or in tangled tufts among other algæ; sheaths colorless, very transparent; trichomes 1-1.5 mic. in diameter, constricted at joints; cells somewhat quadrate **S. hyalina**
  2 Plant mass cæspitose or appressed, semiorbicular; sheaths very thick, lamellose; trichomes 4-9 mic. in diameter, usually solitary within the sheath **S. thelephoroides**
  3 Plant mass indefinite, sheaths purple, orange or rose-colored; trichomes 6-8 mic. in diameter, many within the sheath **S. purpurascens**
  4 Plant mass indefinite, woolly, lead-colored; sheaths very thick, lamellose; trichomes, 7.5-8.5 mic. in diameter **S. chalybea**
  5 Plant mass not cæspitose; sheaths yellowish orange; trichomes 7-13 mic. in diameter; cells somewhat quadrate or twice as short as the diameter **S. muelleri**

II. Cells longer than the diameter
  1 Filaments very long; sheaths dark lead-colored, irregular in outline; trichomes 1.7 mic. in diameter **S. braunii**

2 Filaments forming a loose, cobwebby mass within sandstone rock; sheaths cylindrical, rough, usually colorless and not lamellose, sometimes brownish and lamellose; trichomes 3.5-4.8 mic. in diameter; cells quadrate or a little longer than the diameter **S. rupicola**

Genus DASYGLŒA

Plate XXI, Fig. 48

Sheaths very wide, colorless or yellowish brown; trichomes very few within the sheath, very loosely aggregated; apex of trichome straight, not capitate; cells often longer than the diameter.

Plant mass amorphous, gelatinous; filaments twisted, entangled, divided into fringes at the apex; sheaths sometimes somewhat lamellose; trichomes 4-6 mic. in diameter, constricted at joints; apex of trichome sometimes very gradually tapered; cells 4-13 mic. in length; cell contents coarsely granular **D. amorpha**

Genus MICROCOLEUS

Plate XXI, Fig. 49

Plants living on soil, in fresh water or sometimes in salt water; filaments simple or vaguely branched, creeping on the ground, sometimes growing among other algæ; sheaths colorless, more or less regularly cylindrical, not lamellose, in many species finally diffluent; trichomes many within the sheath in well developed filaments, closely crowded, often twisted into rope-like bundles; apex of trichome straight, tapering; apical cell acute, rarely obtuse conical, in one species capitate.

I. Plants living in salt water; apical cell not capitate, pointed

1 Trichomes 1.5-2 mic. in diameter, constricted at joints **M. tenerrimus**

2 Trichomes 2.5-6 mic. in diameter, constricted at joints **M. chthonoplastes**

II. Plants living on soil; apical cell capitate **M. vaginatus**

III. Plants living in fresh water; apical cell not capitate

1 Sheaths mucous, diffluent; trichomes 4-5 mic. in diameter, especially constricted at joints **M. lacustris**

2 Sheaths somewhat mucous, not or scarcely diffluent; trichomes 5-7 mic. in diameter, not constricted at joints **M. paludosus**

3 Plant mass large, cushion-like; trichomes 5-6 mic. in diameter **M. pulvinatus**

4 Sheaths very mucous and agglutinated; trichomes 6-10 mic. in diameter, especially constricted at joints **M. subtorulosus**

Genus **CATAGNYMENE**

Plate XXI, Fig. 50

Filaments multicellular, floating free, surrounded by thin, close sheaths, enclosed in widely expanded, gelatinous diffluent envelopes, separating easily into fragments through the death of cells.

I. Gelatinous envelope 93-100 mic. in diameter; trichomes up to 16 mic. in diameter, straight or curved **C. pelagica**

11. Gelatinous envelope 150-168 mic. in diameter; trichomes 20-22 mic. in diameter, spirally coiled **C. spiralis**

Genus **HALIARACHNE**

Filaments multicellular, floating free, in somewhat globose or elongate, gelatinous colonies, arranged in two layers, radiating from the center, hooked at the apex; reproduction by division of the colony.

Colony lenticular, 450-700 mic. in diameter; apical cell possessing a calyptra; cells about 8 mic. in diameter, 4-7 mic. in length; cell contents showing gas vacuoles **H. lenticularis**

Family II. NOSTOCACEÆ

Sheaths forming a more or less distinct mucous, gelatinous or membranaceous tegument, mostly confluent, often not present; trichomes consisting of a single row of uniform cells, with heterocysts, usually twisting and entangled, not branched, showing no differentiation of base and apex; reproduction by means of vegetative division, hormogones and gonidia.

I. Sheaths inconspicuous, or mucous and diffluent, or gelatinous, firm and thick
  1 Trichomes flexuous and contorted, forming a plant mass or colony of definite shape
    (1) Colony usually of a rounded or expanded character, gelatinous, made up of dissolved individual sheaths, attached to the substratum or floating free in water; heterocysts intercalary **Nostoc**
    Plate XXI, Fig. 51
    (2) Colony tubular, cylindrical; filaments somewhat straight, parallel, agglutinated **Wollea**
    Plate XXI, Fig. 52
  2 Trichomes more or less straight, free, or forming a thin mucous layer of indefinite shape
    (1) Heterocysts and gonidia intercalary
      A Trichomes free; cells disc-shaped; shorter than their diameter; gonidia seriate, remote from the heterocysts **Nodularia**
      Fig. 53

B Trichomes naked, or with a thin mucous sheath, free or aggregated without order to form a flocculent mass; cells equal to or longer than their diameter; gonidia solitary, in pairs or in short series **Anabæna**
Plate XXII, Fig. 54

C Trichomes short, aggregated in parallel bundles to form thin, feathery, plate-like masses **Aphanizomenon**
Fig. 55

(2) Heterocysts terminal and the gonidia always contiguous to them **Cylindrospermum**
Fig. 56

II. Sheaths thin, membranaceous, persistent; filaments free or agglutinated in a parallel manner

1 Sheaths not present; trichomes single, endophytic; heterocysts terminal **Richelia**
Fig. 57

2 Trichomes single within the sheath; heterocysts intercalary **Aulosira**
Fig. 58

3 Trichomes single within the sheath; heterocysts intercalary and terminal **Microchæte**
Plate XXIII, Fig. 59

4 Trichomes usually many within the sheath, forming a membranaceous or filamentous mass **Hormothamnion**
Fig. 60

Genus **NOSTOC**

Plate XXI, Fig. 51

Plant mass or colony at first globose or oblong, afterwards assuming various forms (globose, foliose, filiform, bullose) in different species, solid or hollow, mucous, gelatinous or leathery, made up of tangled trichomes and their more or less dissolved sheaths; filaments flexuous, curved, entangled, coalesced; sheaths sometimes distinct, sometimes invisible; trichomes often torulose; cells depressed spherical, barrel-shaped or cylindrical; heterocysts intercalary and (in younger plants) terminal; gonidia spherical or oblong, developed centrifugally in series between the heterocysts.

I. Plants living in fresh water; forming minute, disc-shaped specks or patches on aquatic plants; plant mass growing at the periphery; filaments closely contorted **N. cuticulare**

II. Plants living in fresh water, microscopic, granular, aggregated, having the appearance of Aphanocapsa; filaments very closely entangled; trichomes scarcely distinct **N. punctiforme**

III. Plants living in fresh water, very minute; trichomes 2-3.5 mic. in diameter, distinct
  1 Plant mass very minute, punctiform; filaments loosely flexuous; trichomes 3-3.5 mic. in diameter; gonidia about 4 mic. in diameter, 6-8 mic. in length, oblong **N. paludosum**

  2 Plant mass small, adherent, somewhat globose; orange or green; trichomes 2-2.5 mic. in diameter, very short, strongly curved **N. aureum**

  3 Plant mass small, gelatinous, membranaceous, soft, green, blue-green or brownish; trichomes 3-4 mic. in diameter, flexuously curved, somewhat densely entangled **N. comminutum**

IV. Plants living in fresh water; plant mass large, gelatinous, fragile, at first spherical, afterwards becoming torn and irregularly expanded
  1 Filaments numerous, abruptly contorted, entangled; trichomes 3.5-4 mic. in diameter; gonidia 6-7 mic. in diameter, 7-8 mic. in length **N. linckia**

  2 Filaments flexuous, loosely entangled
    (1) Gonidia 6-7 mic. in diameter, spherical; wall of gonidium smooth; trichomes 4 mic. in diameter **N. piscinale**

    (2) Gonidia olong; wall of gonidium smooth
      A Trichomes 4-4.2 mic. in diameter; gonidia 6-8 mic. in diameter, 7-10 mic. in length, contiguous; wall of gonidium becoming brownish or colorless **N. rivulare**

      B Trichomes 3.5-4 mic. in diameter; gonidia 6 mic. in diameter, 8-10 mic. in length, not contiguous; wall of gonidium colorless **N. carneum**

      C Trichomes 4 mic. in diameter; cells different in shape, some cylindrical, others barrel-shaped or spherical depressed; gonidia 6-7 mic. in diameter, 10-12 mic. in length, not contiguous; wall of gonidium colorless or becoming yellowish **N. spongiæforme**

V. Plants living on soil; colonies gelatinous, soft, at first spherical, soon confluent and flattened, attached to soil or mosses
  1 Cells cylindrical; trichomes 4 mic. in diameter; gonidia 6-8 mic. in diameter
    (1) Gonidia 14-19 mic. in length; wall of gonidium smooth **N. ellipsosporum**

    (2) Gonidia 8-14 mic. in length; wall of gonidium furnished with short spines **N. gelatinosum**

2 Cells oval, spherical or spherical depressed
  (1) Trichomes 3-4 mic. in diameter; gonidia 4-8 mic. in diameter, 8-12 mic. in length, oblong, in a catenate series **N. muscorum**
  (2) Trichomes 2.2-3 mic. in diameter; gonidia 4 mic. in diameter, 6 mic. in length, oval **N. humifusum**

VI. Plants living on soil, sometimes submerged; colonies free, at first spherical, then expanding symmetrically or irregularly; cells somewhat globose
  1 Colonies gelatinous, spongy, lacunose, somewhat pellucid, green, olive or brownish; trichomes 4 mic. in diameter; gonidia 7 mic. in diameter, 7-10 mic. in length, often oval; wall of gonidium smooth, colorless **N. foliaceum**
  2 Colonies expanded, irregular or orbicular, very thin, small, membranaceous, pellucid, blue-green; trichomes 4 mic. in diameter **N. punctatum**
  3 Colonies at first spherical, afterwards becoming flattened and finally spreading out into irregular, membranaceous sheets; surrounded by a firm outer layer; trichomes 4-5.6 mic. in diameter **N. commune**
  4 Colonies free, spherical, becoming irregularly plicate-tuberculate, thick, solid, surrounded by a firm outer layer; trichomes 4-5 mic. in diameter; gonidia 5 mic. in diameter, 7 mic. in length, oval; wall of gonidium thick, smooth, becoming brownish **N. sphæricum**
  5 Colonies spherical, finally becoming flattened, membranaceous; trichomes 2.5-3 mic. in diameter **N. minutum**
  6 Plants living in hot water; colonies indefinitely expanded, laciniate; filaments 2 mic. (?) in diameter **N. calidarium**
  7 Colonies somewhat spherical, small, very hard, sometimes soft, with surface often corrugated; trichomes 6.5-8.2 mic. in diameter **N. austinii**

VII. Plants living on soil or in fresh water; colonies spherical, surrounded by a firm outer layer
  1 Plants living on soil
    (1) Colonies small; trichomes 8-9 mic. in diameter; gonidia somewhat spherical, two or three times larger than the cells; wall of gonidium thin, very smooth **N. macrosporum**
    (2) Colonies spherical or oblong, rarely beyond 1 cm. in diameter, somewhat pellucid; trichomes 5-8 mic. in diameter; gonidia 6-7 mic. in diameter, 9-15 mic. in length, oval **N. microscopicum**

(3) Colonies small or of medium size, spherical; trichomes 4-7 mic. in diameter; gonidia 6-7 mic. in diameter, exactly spherical; wall of gonidium somewhat thick, rough **N. sphæroides**

2 Plants living in fresh water

(1) Colonies irregularly somewhat orbicular, gregarious and sometimes aggregated; trichomes 5 mic. in diameter **N. depressum**

(2) Colonies spherical, usually aggregated in grape-like clusters; trichomes 3.5-4 mic. in diameter **N. glomeratum**

(3) Colonies gregarious, pellucid, sky blue or blue-green; trichomes 5-7 mic. in diameter; cells barrel-shaped **N. cæruleum**

(4) Colonies spherical, surrounded by a leathery outer layer; trichomes 4-6 mic. in diameter **N. pruniforme**

VIII. Plants living in fresh water, attached; colonies somewhat spherical, bullate, rarely disc-shaped, surrounded by a firm outer layer; trichomes slender

1 Trichomes 3-3.5 mic. in diameter, especially cylindrical; gonidia 5 mic. in diameter, 7 mic. in length; wall of gonidium smooth **N. verrucosum**

2 Trichomes 2-3 mic. in diameter, distinctly torulose; gonidia 3-4 mic. in diameter, 5-6 mic. in length; wall of gonidium smooth, brown **N. amplissimum**

3 Filaments radiating from the center, flexuous, very densely twisted and entangled near the surface; trichomes 4-4.5 mic. in diameter; gonidia 4-5 mic. in diameter, 7-8 mic. in length, oval; wall of gonidium smooth, yellowish **N. parmelioides**

Genus **WOLLEA**

Plate XXI, Fig. 52

Plant mass or colony tubular, cylindrical, somewhat membranaceous, soft; filaments somewhat straight, parallel or slightly curved, agglutinated; sheaths confluent; heterocysts intercalary; gonidia catenate, contiguous to the heterocysts or remote from them.

Trichomes 4-5 mic. in diameter, numerous, erect, parallel or slightly curved; cells oblong or cylindrical, closely connected; heterocysts 6 mic. in diameter, oval or somewhat spherical, yellow or pale orange; gonidia 7 mic. in diameter, 15-22 mic. in length, numerous, cylindrical, catenate **W. saccata**

Genus NODULARIA

Plate XXI, Fig. 53

Filaments free; sheaths colorless, close, usually thin, mucous, sometimes diffluent; trichomes more or less straight; cells short, depressed, disc-shaped; heterocysts depressed; gonidia spherical, somewhat spherical or disc-shaped, developed in series between the heterocysts; wall of gonidium smooth.

I. Trichomes less than 8 mic. in diameter

1 Filaments 4-6 mic. in diameter; gonidia 6-8 mic. in diameter, somewhat spherical **N. harveyana**

2 Filaments 6-7 mic. in diameter; gonidia 7-10 mic. in diameter, spherical depressed **N. sphærocarpa**

3 Trichomes 6-8 mic. in diameter; cells short, about half as long as wide **N. paludosa**

II. Filaments more than 8 mic. in diameter

1 Trichomes 7.5-9.5 mic. in diameter; cells nearly as long as broad before division **N. hawaiiensis**

2 Filaments 10-11 mic. in diameter; gonidia 10-12 mic. in diameter, 9 mic. in length, spherical depressed, in series **N. armorica**

3 Filaments 8-18 mic. in diameter; gonidia 12-15 mic. in diameter, 6-10 mic. in length; somewhat spherical or elliptical **N. spumigena**

4 Trichomes (?) 33-38 mic. in diameter; cells short **N. mainensis**

Genus ANABÆNA

Plate XXII, Fig. 54

Sheaths not present or when present often diffluent; trichomes equal throughout or tapering at the apices, usually rigid and fragile, sometimes circinate, free or aggregated without order to form a flocculent mass; cells equal to or longer than their diameter; apical cells sometimes conical; heterocysts numerous and intercalary; gonidia variously disposed, sometimes solitary, sometimes lying on each side of a heterocyst, rarely in short catenate series.

I. Gonidia oval or spherical

1 Gonidia oval or barrel-shaped, remote from the heterocysts in catenate series

(1) Wall of gonidium smooth **A. variabilis**

(2) Wall of gonidium papillose **A. hallensis**

2 Gonidia spherical, contiguous to heterocysts, solitary or in short series, 12-20 mic. in diameter **A. sphærica**

II. Gonidia variously disposed, sometimes contiguous to heterocysts, sometimes remote from them, cylindrical, straight or curved

1 Trichomes usually circinate; gonidia curved, obliquely truncate at the apices

(1) Gonidia 7-13 mic. in diameter, 20-50 mic. in length, curved, oblique, inequilateral, contiguous to or rarely remote from the heterocysts; wall of gonidium smooth, colorless or yellowish; trichomes 4-8 mic. in diameter **A. flos-aquæ**

(2) Gonidia 16-18 mic. in diameter, up to 30 mic. in length, curved, oblique or cylindrical, the younger ones somewhat spherical, usually remote from the heterocysts; wall of gonidium smooth, colorless; trichomes 8-14 mic. in diameter **A. circinalis**

2 Trichomes straight; gonidia cylindrical, straight, usually remote from the heterocysts, solitary or in series

(1) Trichomes 4-5 mic. in diameter; sheaths sometimes present; gonidia 14-17 mic. in length **A. inæqualis**

(2) Trichomes 5-8 mic. in diameter; sheaths occasionally present; gonidia 7-10 mic. in diameter, up to 30 mic. and more in length **A. catenula**

(3) Trichomes 4.2-6 mic. in diameter; sheaths present; gonidia 6 mic. in diameter, 14-20 mic. in length **A. laxa**

III. Gonidia contiguous to heterocysts on each side, developed centripetally, cylindrical or somewhat cylindrical

1 Gonidia 7-12 mic. in diameter, 18-28 mic. in length, short, somewhat cylindrical, often slightly constricted in the center; apical cell conical **A. torulosa**

2 Gonidia 8-10 mic. in diameter, 20-40 mic. in length, especially cylindrical; apical cells obtuse **A. oscillarioides**

3 Gonidia 15-20 mic. in diameter, 50-90 mic. in length, cylindrical or more commonly tapering slightly from the middle to the rounded ends **A. bornetiana**

Genus APHANIZOMENON

Plate XXII, Fig. 55

Colonies thin, feathery, plate-like or spindle-shaped bundles, blue-green, floating; sheaths not present; trichomes short, tapering at the ends, agglutinated; heterocysts scattered; gonidia cylindrical, much elongated, solitary, developed sparingly between the heterocysts.

Colonies small, aggregated in membranaceous flakes, fragile; trichomes 5-6 mic. in diameter, rigid; cells somewhat quadrate, 5-15 mic. in length; heterocysts 6-7 mic. in diameter, 15-20 mic. in length, somewhat cylindrical; gonidia 7-8 mic. in diameter, 60-80 mic. in length, containing granular protoplasm; wall of gonidium smooth, colorless **A. flos-aquæ**

Genus CYLINDROSPERMUM

Plate XXII, Fig. 56

Plant mass expanded, indefinite, mucous; sheaths not present; trichomes equal, short, embedded in an amorphous mucus; cells cylindrical, longer than their diameter; heterocysts terminal, solitary; gonidia developed from the cell or cells next the heterocyst, generally solitary, rarely seriate.

I. Gonidia solitary
  1 Gonidia cylindrical, up to 40 mic. in length
    (1) Gonidia 10-16 mic. in diameter, 32-40 mic. in length **C. stagnale**

    (2) Gonidia 11-12 mic. in diameter, 23-24 mic. in length **C. comatum**

  2 Gonidia oblong or ventricose-elliptical
    (1) Wall of gonidium punctate
      A Gonidia 10-15 mic. in diameter, 20-38 mic. in length, ventricose-elliptical; wall of mature gonidium rough, punctate **C. majus**

      B Gonidia 6-6.5 mic. in diameter, 16-19 mic. in length, elliptical; wall of gonidium very finely granular **C. minutum**

    (2) Wall of gonidium smooth
      A Gonidia 8-9 mic. in diameter, 18-20 mic. in length **C. minutissimum**

      B Gonidia 9-12 mic. in diameter, 18-20 mic. in length **C. muscicola**

      C Gonidia 12-14 mic. in diameter, 20-38 mic. in length **C. licheniforme**

II. Gonidia seriate **C. catenatum**

Genus RICHELIA

Plate XXII, Fig. 57

Sheaths not present; trichomes single, endophytic; heterocysts solitary, situated at the base of the trichome.

Trichomes 5.6-9-8 mic. in diameter, 50-105 mic. in length, short, straight or nearly straight, thickened at the apices; heterocysts 9.8-11.2 mic. in diameter **R. intracellularis**

Genus **AULOSIRA**

Plate XXII, Fig. 58

Filaments free, equal, scattered or in fascicles; sheaths membranaceous, close; cells cylindrical or barrel-shaped; heterocysts intercalary; gonidia developed at intervals between the heterocysts, remote from or contiguous to them, cylindrical, in catenate series.

Filaments 10-11 mic. in diameter; trichomes 9.5 mic. in diameter; cells 3 mic. in length; heterocysts usually 9.5 mic. in diameter, 11 mic. in length, always intercalary **A. schauinslandii**

Genus **MICROCHÆTE**

Plate XXIII, Fig. 59

Plants small, living in fresh or salt water, aggregated into star-shaped or cushion-shaped tufts; filaments unbranched, erect, attached at the base; sheaths present; trichomes single within the sheath; heterocysts basal and intercalary; gonidia developed from the lower cells.

I. Plants living in fresh water; heterocysts basal and intercalary
  1 Filaments 4.4-5.1 mic. in diameter; sheaths colorless, wide **M. tenuissima**
  2 Filaments 10 mic. in diameter; sheaths simple, thin, close **M. tenera**
  3 Filaments 16-18 mic. in diameter; sheaths at first thin, later becoming lamellose, colorless **M. robusta**

II. Plants living in salt water; heterocysts basal
  1 Plant mass densely cæspitose; filaments 6-7 mic. in diameter, thickened into a bulb at the base **M. grisea**
  2 Plant mass loosely cæspitose; filaments 7-9 mic. in diameter, flexuous, scarcely thickened at base **M. vitiensis**

Genus **HORMOTHAMNION**

Plate XXIII, Fig. 60

Plant mass formed from filaments growing together in a longitudinal manner, sometimes developing as an expanded layer, sometimes erect, filiform, torn and branched, not surrounded by a common gelatinous tegument; sheaths membranaceous, thin, often diffluent, colorless; trichomes moniliform; usually many within the sheath; heterocysts intercalary; gonidia not known.

I. Plant mass floccose, entangled; trichomes 9-12 mic. in diameter **H. solutum**

II. Plant mass erect, cæspitose, resembling Symploca; trichomes 6-7 mic. in diameter **H. enteromorphoides**

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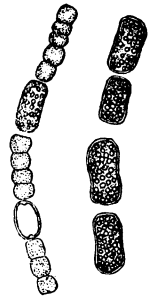

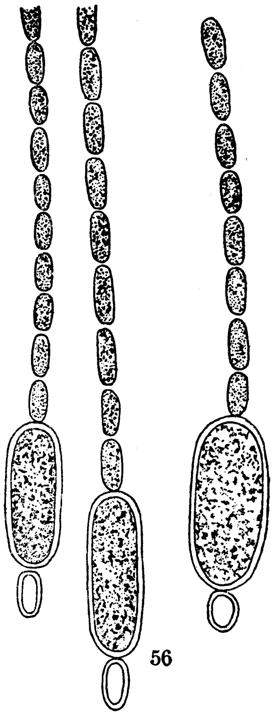

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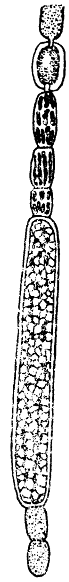

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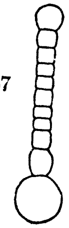

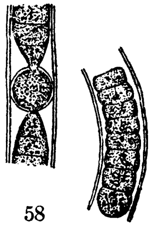

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Plate XXII

Family III. SCYTONEMACEÆ

Filaments branched; false branches formed by the perforation of the sheath by the trichome which thereupon issues as one or two long, flexuous branches each developing a sheath of its own; sheaths homogeneous and colorless, or lamellose and yellowish or brownish, firm, tubular; trichomes consisting of a single row of cells, one or more included in a sheath; heterocysts and gonidia variously disposed; reproduction by means of vegetative division, hormogones and gonidia.

I. Trichomes single within the sheath
  1 Heterocysts not present; filaments free or forming felt-like masses, branched; false branches often in pairs **Plectonema**
  Plate XXIV, Fig. 61
  2 Heterocysts present
    (1) False branches usually arising between two heterocysts, single or in pairs; sheaths delicate or very thick, parallel, or more or less diverging towards the apex **Scytonema**
    Plate XXV, Fig. 62
    (2) False branches usually arising in the immediate region of the heterocysts, single; sheaths somewhat thin, flexible, more or less fragile **Tolypothrix**
    Fig. 63
II. Trichomes or filaments several within the sheath
  1 Filaments straight, associated in tufts; sheaths thin; trichomes two or more within the sheath; heterocysts basal **Desmonema**
  Fig. 64
  2 Filaments several contorted within a common tegument, associated in a gelatinous stratum; trichomes single within the sheath **Diplocolon**
  Fig. 65

Genus PLECTONEMA

Plate XXIII, Fig. 61

Filaments free or forming felt-like masses, branched; false branches solitary or in pairs; sheaths firm, colorless or rarely yellowish orange; trichomes frequently constricted at the joints; apex of trichome straight, very rarely tapering; calyptra none.

I. Plants large, cæspitose; trichomes 3 mic. and more in diameter
  1 Plant mass cæspitose, rotund, light green; trichomes 5-10 mic. in diameter, here and there constricted at joints **P. tenue**
  2 Plant mass cæspitose, indefinite, brownish green; trichomes 11-22 mic. in diameter **P. tomasinianum**

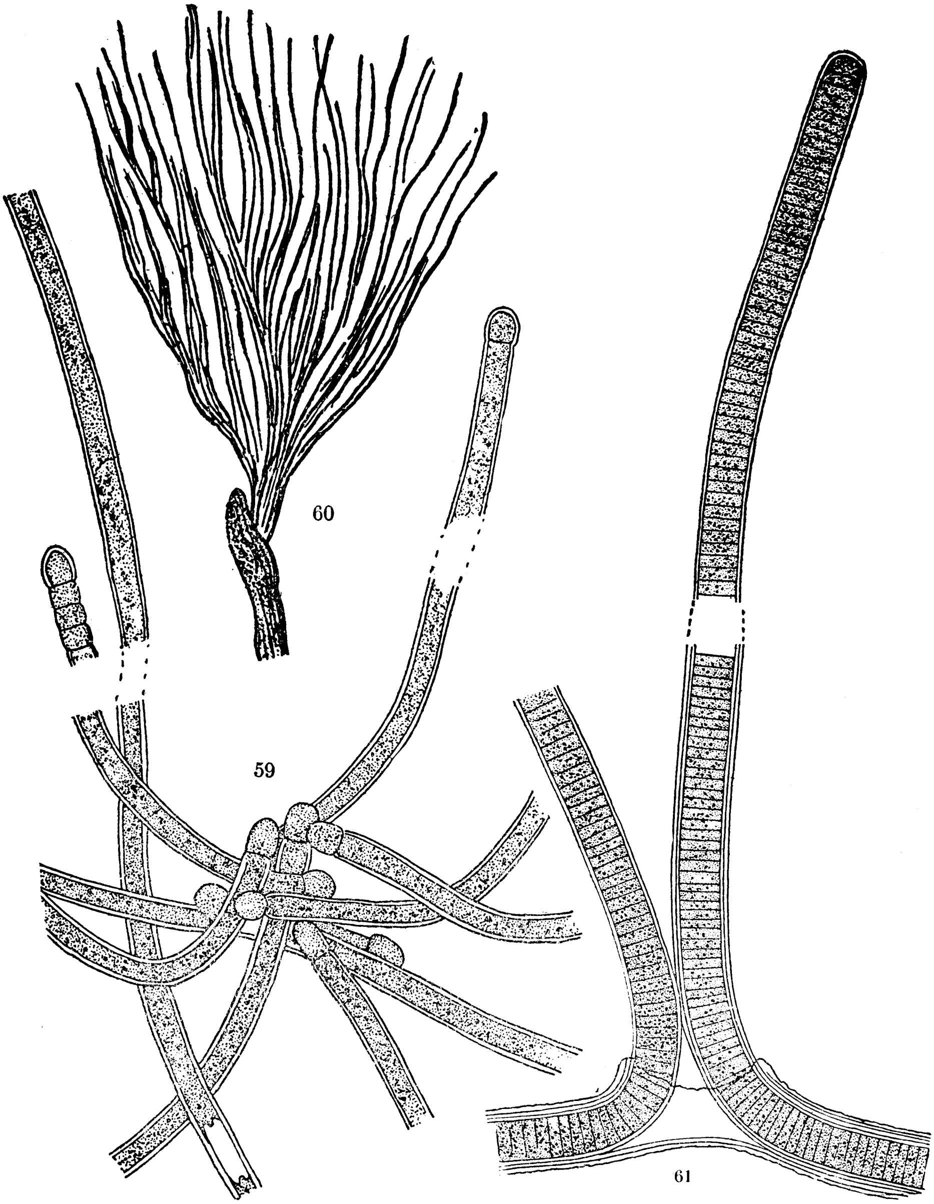

PLATE XXIII

3 Plant mass widely expanded, indefinite, blackish, rarely yellowish green; trichomes 28-47 mic. in diameter, not constricted at joints **P. wollei**

II. Plant mass very thin, not cæspitose; trichomes 1-4 mic. in diameter

1 Filaments somewhat flexuous, immersed in dead shells; trichomes .9-1.5 mic. in diameter, not constricted at joints **P. terebrans**

2 Filaments somewhat straight, growing among various gelatinous algæ; trichomes 1-1.5 mic. in diameter **P. nostocorum**

3 Filaments usually strongly flexuous, densely entangled in a rose-colored membrane; trichomes 1.2-1.8 mic. in diameter **P. roseolum**

4 Filaments long, entangled, flexuous, much branched, forming a rose-colored or reddish brown mass adhering to rocks or larger algæ; trichomes 1.2-2 mic. in diameter **P. golenkinianum**

5 Filaments very long, entangled in dense balls; trichomes 2-2.5 mic. in diameter **P. calothrichoides**

6 Filaments long, flexuous, much branched, forming a black or brownish green mass; trichomes 2-3.5 mic. in diameter **P. battersii**

Genus SCYTONEMA

Plate XXIV, Fig. 62

Filaments branched; false branches usually arising between two heterocysts, solitary or in pairs, formed by the lateral perforation of the sheath by the trichome; trichomes single within the sheath, straight; hormogones terminal, solitary; gonidia spherical or oval, observed in a few species; wall of gonidium thin, smooth.

I. Sheaths homogeneous or formed of parallel layers

1 Plants living in fresh water

(1) Filaments 5-8 mic. in diameter **S. conchophilum**

(2) Filaments 12-16 mic. in diameter **S. arcangelii**

(3) Filaments 18-24 mic. in diameter **S. coactile**

(4) Filaments about 30 mic. in diameter **S. rivulare**

(5) Filaments 36 mic. in diameter **S. occidentale**

(6) Filaments 16-36 mic. in diameter **S. crispum**

2 Plants living in warm water

(1) Filaments 16 mic. in diameter **S. caldarium**

(2) Filaments 25 mic. in diameter **S. azureum**

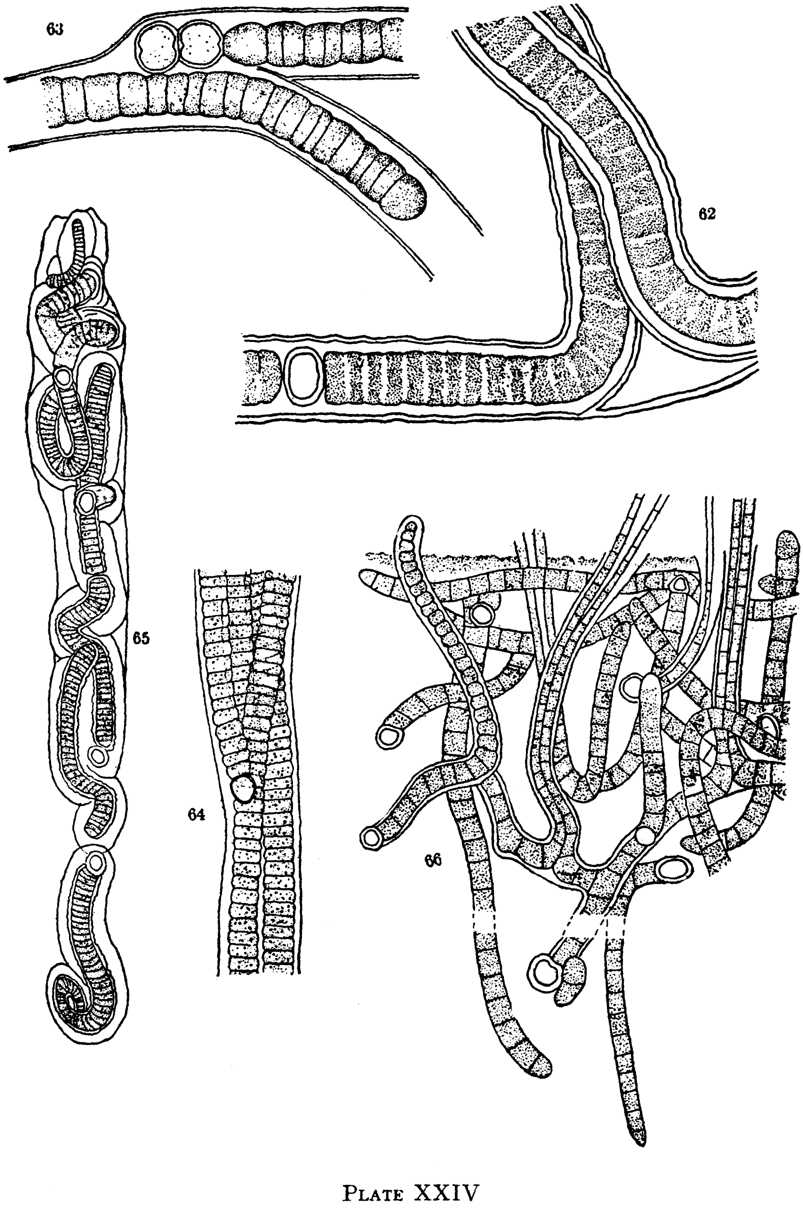

Plate XXIV

3 Plants living on soil, rocks, or bark, not submerged
  (1) Filaments 7-15 mic. in diameter **S. hofmanni**
  (2) Filaments 9-15 mic. in diameter **S. varium**
  (3) Filaments 12-15 mic. in diameter **S. javanicum**
  (4) Filaments 10-18 mic. in diameter **S. ocellatum**
  (5) Filaments up to 20 mic. in diameter **S. intertextum**
  (6) Filaments 15-20 mic. in diameter **S. austinii**
  (7) Filaments 15-21 mic. in diameter; cells compressed **S. millei**
  (8) Filaments 15-21 mic. in diameter; cells somewhat quadrate or elongate **S. guyanense**
  (9) Filaments 19-24 mic. in diameter **S. amplum**
  (10) Filaments 20-25 mic. in diameter **S. wolleanum**
  (11) Filaments 16-30 mic. in diameter **S. stuposum**

II. Sheaths lamellose, with diverging layers; plants usually living on soil or rocks, not submerged
  1 Filaments 10-15 mic. in diameter **S. tolypotrichoides**
  2 Filaments 12-18 mic. in diameter **S. flavo-viride**
  3 Filaments 15-21 mic. in diameter **S. mirabile**
  4 Filaments 18-36 mic. in diameter **S. myochrous**
  5 Filaments 40-75 mic. in diameter **S. badium**

III. Sheaths thick, lamellose, forming wings or membranaceous expansions (ocreæ); branches in basal portion of filament issuing in pairs, those in the upper portion solitary
  1 Plants living in water
    (1) Plants living in salt water; filaments 28-50 mic. in diameter **S. fuliginosum**
    (2) Plants living in fresh water, on dripping rocks or submerged **S. alatum**
  2 Plants living on damp rocks or on bark
    (1) Filaments 12-16 mic. in diameter **S. junipericolum**
    (2) Filaments 15-30 mic. in diameter **S. crustaceum**
    (3) Filaments 24-40 mic. in diameter **S. densum**

Genus TOLYPOTHRIX

Plate XXIV, Fig. 63

Filaments branched; false branches usually arising in the immediate region of the heterocysts, rarely between two heterocysts, single; sheaths somewhat thin, flexible, more or less fragile; gonidia spherical, oval or elliptical, often many in a series; wall of gonidium smooth, thin.

I. Sheaths thin	
1 Plants living in water	
(1) Filaments 8-10 mic. in diameter	**T. tenuis**
(2) Filaments 9-12.5 mic. in diameter	**T. lanata**
(3) Filaments 10-15 mic. in diameter	**T. distorta**
(4) Filaments 12-17 mic. in diameter	**T. penicillata**
2 Plants living in moist places	
(1) Filaments 10-15 mic. in diameter	**T. byssoidea**
(2) Filaments 15-25 mic. in diameter	**T. ravenelii**
II. Sheaths thick	
1 Plants living in water	
(1) Filaments 5-6 mic. in diameter	**T. setchellii**
(2) Filaments 12-15 mic. in diameter	**T. limbata**
2 Plants living in moist places; filaments 12-15 mic. in diameter	**T. rupestris**

Genus DESMONEMA

Plate XXIV, Fig. 64

Plant mass cæspitose, penicillate; filaments somewhat dichotomously divided, straight; sheaths thin; trichomes two or more within the sheath; heterocysts basal; gonidia large, oval or elliptical, single or in short series; wall of gonidium somewhat thick.

Plant mass 5-6 mm. in height, formed of penicillate fascicles; filaments erect, repeatedly sub-dichotomously branched; trichomes 9-10 mic. in diameter, constricted at the joints; cells three times shorter than the diameter; heterocysts one, two or none **D. wrangelii**

Genus DIPLOCOLON

Plate XXIV, Fig. 65

Plant mass gelatinous, terrestrial; colonies irregular in shape, constricted, somewhat club-shaped; filaments several, contorted within a common tegument, branched; false branches solitary or in pairs, usually arising between two heterocysts, but rarely in the immediate region of the heterocysts; trichomes single within the sheath.

Colonies club-shaped, gelatinous, irregularly dilated, up to 1 mm. in thickness, yellowish brown; filaments 20-28 mic. in diameter; trichomes constricted at joints; cells and heterocysts 6-10 mic. in diameter, somewhat spherical **D. heppii**

Family IV. STIGONEMACEÆ

Filaments free, rarely laterally aggregated, scattered, frequently branched; sheaths thick, firm, often irregular; trichomes consisting of one or several rows of cells, with heterocysts; heterocysts often lateral, sometimes intercalary; reproduction by means of vegetative division, hormogones and gonidia.

I. Sheaths distinct, definite
  1 Filaments free
    (1) Trichomes consisting of one row of cells
      A Branches of two kinds, the one cylindrical, the other flagelliform; heterocysts terminal or lateral **Mastigocoleus** Plate XXIV, Fig. 66
      B Branches unilateral, usually tapering at the apex; heterocysts intercalary **Hapalosiphon** Plate XXV, Fig. 67
    (2) Trichomes consisting of one to several rows of cells
      A Branches unilateral, thin, finally forming hormogones **Fischerella** Figs. 68, 69
      B Branches scattered; hormogones formed in the apices of the branches or in special short branches **Stigonema** Fig. 70
  2 Filaments growing together forming a cushion-like mass **Capsosira** Fig. 71
II. Sheaths confluent into a gelatinous amorphous mass **Nostochopsis** Plate XXVI, Fig. 72

Genus MASTIGOCOLEUS

Plate XXIV, Fig. 66

Filaments free, irregularly branched; branches of two kinds, the one cylindrical, the other flagelliform, tapering off into a hair-like apex; sheaths continuous; trichomes, except in the branches, single within the sheath; heterocysts single, rarely in pairs, terminal or lateral, sometimes intercalary; gonidia unknown; reproduction by means of hormogones; cell contents homogeneous.

Filaments 6-10 mic. in diameter; trichomes 3.5-6 mic. in diameter; heterocysts 6-18 mic. wide and long; cell contents greenish **M. testarum**

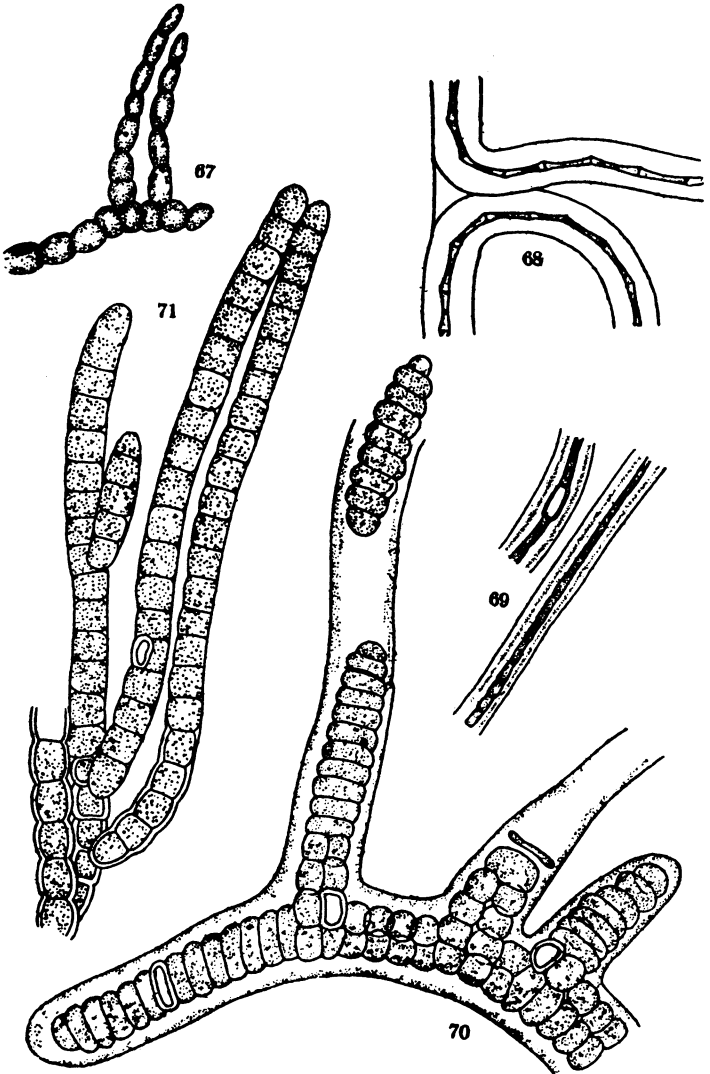

Plate XXV

Genus HAPALOSIPHON

Plate XXV, Fig. 67

Plant mass cæspitose-floccose, thin, aquatic; filaments free, not growing together laterally, branched, consisting of a single row of cells, rarely of two rows, enclosed within a sheath; branches erect, usually about the same thickness as the creeping primary filament, commonly unilateral, long, flexuous, very slightly tapering; sheaths continuous, strong, of uniform thickness; sheaths of the branches thinner than those of primary filaments, usually colorless; heterocysts intercalary; wall of gonidium thick, yellowish brown.

I. Plants living in fresh water
  1 Filaments decumbent, branched on all sides; branches 6-8 mic. in diameter; cells elliptical depressed **H. flexuosus**
  2 Plant mass cæspitose, orange brown; primary filaments 11.5-12.5 mic. in diameter; trichomes 7.5-8 mic. in diameter **H. aureus**
  3 Plant mass floccose, cæspitose, dull blue-green; primary filaments 21-24 mic. in diameter **H. fontinalis**

II. Plants living in hot water
  1 Plant mass cushion-like, irregular or expanded, blue-green; primary filaments 3-6 mic. in diameter **H. laminosus**
  2 Plant mass widely expanded, bright blue-green; trichomes 3-11 mic. in diameter **H. major**

III. Plants living on bark of trees
  1 Plant mass cæspitose, small, blue-green; filaments 4-7 mic. in diameter **H. intricatus**
  2 Filaments 7-10 mic. in diameter; trichomes 7-9.5 mic. in diameter **H. arboreus**

Genus FISCHERELLA

Plate XXV, Figs. 68, 69

Plant mass forming a continuous, more or less expanded layer, terrestrial; filaments of two kinds; primary filaments creeping, containing one or two rows of cells, unilaterally very much branched; branches or secondary filaments erect, elongate, more slender than the primary, containing very long hormogones within the sheath.

I. Plants living in moist places; primary filaments 6-9 mic. in diameter **F. ambigua**

II. Plants living in moist places or in hot water; primary filaments 10-13 mic. in diameter **F. thermalis**

Genus **STIGONEMA**

Plate XXV, Fig. 70

Plants terrestrial or aquatic; plant mass rigid, blackish brown, or cushion-like and soft; filaments free, rarely laterally aggregated, scattered; trichomes, in the larger filaments, consisting of two or several rows of cells; heterocysts often lateral, here and there intercalary, hormogones developed in the apices of vegetative branches or in short special branches.

I. Trichomes in the mature filaments consisting usually of a single row of cells

  1 Filaments 7-15 mic. in diameter; sheaths usually colorless **S. hormoides**

  2 Filaments 25 mic. in diameter; cells 14 mic. in diameter, 6-8 mic. in length **S. ærugineum**

  3 Filaments 24-26 mic. in diameter; sheaths thick, lamellose **S. panniforme**

  4 Filaments 14-38 mic. in diameter, sheaths yellowish brown **S. tomentosum**

  5 Filaments 24-45 mic. in diameter; sheaths thick, lamellose, colorless or yellowish brown **S. ocellatum**

II. Trichomes in the mature filaments consisting usually of two or several rows of cells

  1 Filaments up to 35 mic. in diameter

    (1) Filaments 18-28 mic. in diameter; cells often surrounded by a special darker colored envelope **S. minutum**

    (2) Filaments 27-37 mic. in diameter; cells throughout the entire length of the filament uniformly divided **S. turfaceum**

  2 Filaments 40-90 mic. in diameter

    (1) Hormogones 45 mic. in length, terminal, solitary or in series **S. informe**

    (2) Plants rigid; hormogones 45 mic. in length, lateral **S. mamillosum**

Species not well understood **S. brandegeei**

Genus **CAPSOSIRA**

Plate XXV, Fig. 71

Plant mass hemispherical, cushion-like, attached by lower surface, formed of filaments growing together laterally, aquatic; filaments erect, branched, composed of a single row of cells; sheaths septate; heterocysts intercalary and lateral; hormogones composed of from 10-20 cells; gonidia spherical; wall of gonidium thick, brownish.

Filaments 7.5 mic. in diameter; cells 4-5 mic. in diameter; heterocysts lateral **C. brebissonii**

Genus NOSTOCHOPSIS

Plate XXVI, Fig. 72

Plant mass or colony gelatinous, definite, aquatic; trichomes formed of a single row of cells, branched; heterocysts intercalary and lateral, pedicellate or sessile.

Colony, hollow; trichomes 4-9 mic. in diameter, 1 mm. in length; branches unilateral, fastigiate, cylindrical below, torulose in upper portions, somewhat club-shaped; heterocysts lateral, exserted, or intercalary **N. lobatus**

Family V. RIVULARIACEÆ

Filaments tapering from base to apex, ending in a colorless hair, simple or branched; false branches due to development of new trichome from a cell of the main trichome, usually occurring immediately under an intercalary heterocyst—rarely by the perforation of the sheath between two heterocysts by the trichome, as in Scytonema—either separating immediately and forming a new sheath, or remaining for some time within the original sheath; heterocysts usually present, usually basal, occasionally intercalary; reproduction by means of vegetative division, hormogones and gonidia.

I. Heterocysts not present **Amphithrix**
Plate XXVII
Fig. 73

II. Heterocysts present
  1 Filaments free, simple or coalesced into a branched plant mass
    (1) Sheaths cylindrical
      A Filaments simple or branched; false branches distinct, free **Calothrix**
      Fig. 74

      B Filaments branched; false branches several (two to six) remaining within the original sheath or common tegument **Dichothrix**
      Fig. 75

      C Filaments branched; false branches many (up to a hundred) remaining within the original sheath or common tegument **Polythrix**

    (2) Sheaths thick, saccate **Sacconema**
    Plate XXVIII
    Fig. 76

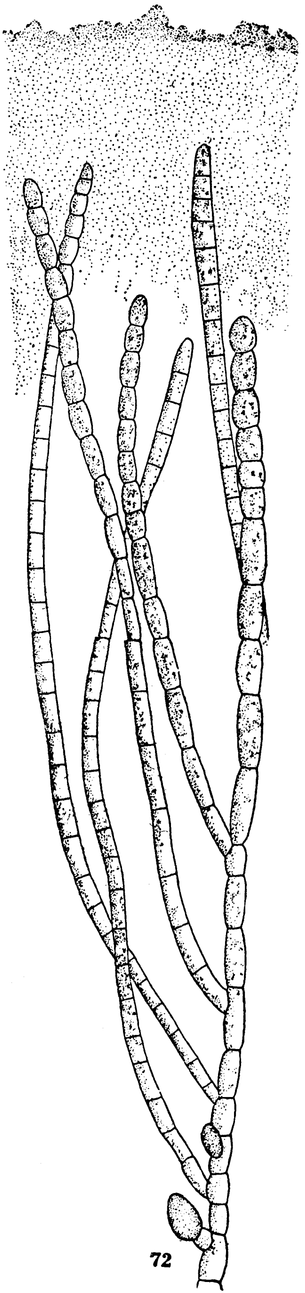

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Plate XXVI

2 Filaments coalesced into a crustaceous, spherical or hemispherical, mucous or gelatinous plant mass or colony
  (1) Heterocysts basal
    A Filaments simple, parallel, associated in a crustaceous layer **Isactis**
    Plate XXIX, Fig. 77
    B Filaments branched, radially arranged, associated in a spherical or hemispherical colony **Rivularia**
    Fig. 78
  (2) Heterocysts intercalary **Brachytrichia**
  Fig. 79

Genus AMPHITHRIX

Plate XXVII, Fig. 73

Plant mass crustaceous or cæspitose, thin, expanded, of a purple or violet color, consisting of two layers: the lower layer composed of densely interwoven filaments or of minute, radiately disposed series of cells; the upper layer consisting of simple erect filaments, closely packed together and tapering to fine points; sheaths thin, close, continuous; hormogones solitary or in series; heterocysts not present.

I. Plant mass crustaceous; filaments 1.5-2.2 mic. in diameter; 3-5 decimill. in length; cells equal to the diameter in length **A. janthina**

II. Plant mass cæspitose; filaments 2-3 mic. in diameter, 1-3 mm. in length; cells shorter than their diameter **A. violacea**

Genus CALOTHRIX

Plate XXVII, Fig. 74

Plant mass consisting of penicillate tufts or a soft velvety expansion; filaments simple or slightly branched; heterocysts basal or intercalary, absent in a few species; gonidia basal, seriate.

I. Heterocysts not present **C. juliana**
II. Heterocysts present
  1 Plants living in salt water
    (1) Heterocysts basal
      A Plants fasciculate or penicillate, parasitic
        a Filaments 12-15 mic. in diameter **C. confervicola**
        b Filaments 21-29 mic. in diameter **C. consociata**
      B Plants cæspitose, often growing on rocks
        a Filaments 8-12 mic. in diameter; cell contents violet **C. fusco-violacea**
        b Filaments 10-18 mic. in diameter; cell contents olive green **C. scopulorum**

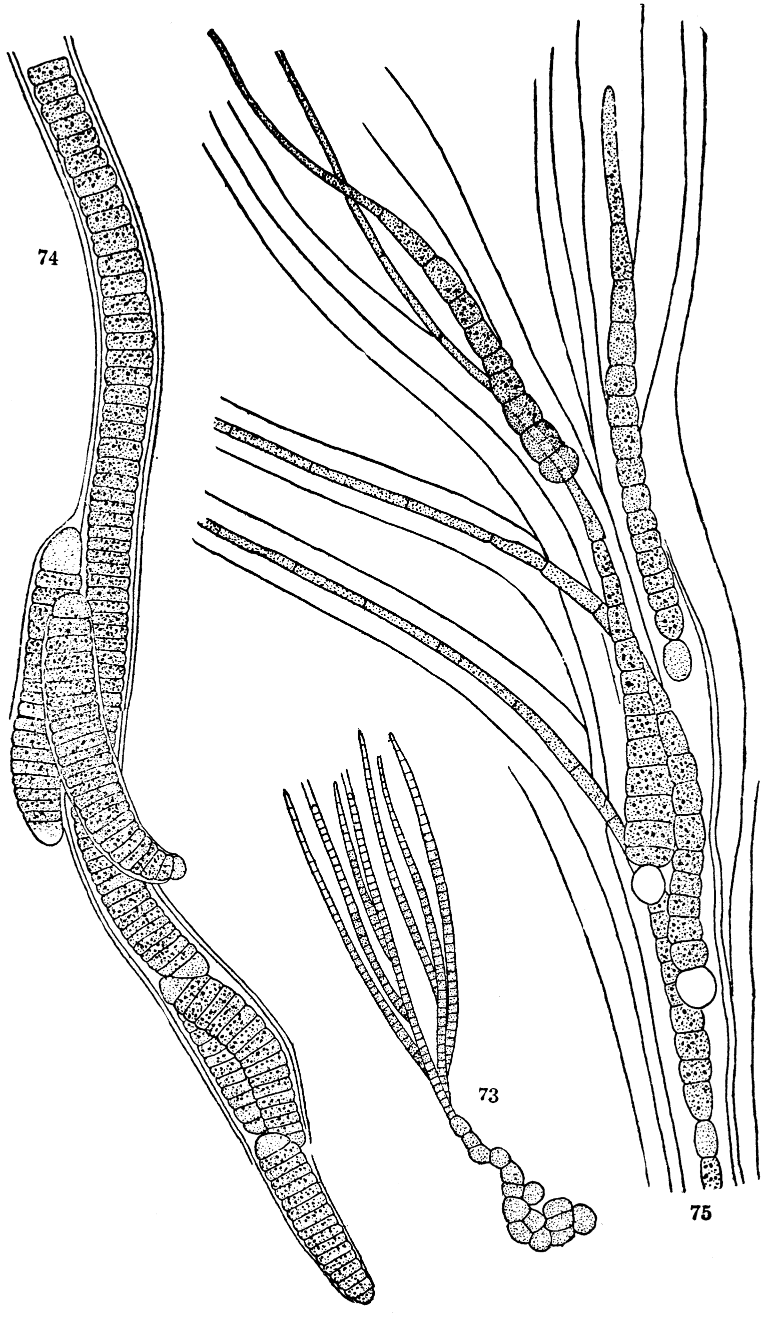

Plate XXVII

c Filaments 9-15 mic. in diameter; cell contents olive green **C. contarenii**

d Filaments 15-20 mic. in diameter; cell contents olive green **C. pulvinata**

e Plants parasitic; filaments 9-15 mic. in diameter, thickened into a bulb at the base; cell contents blue-green **C. parasitica**

(2) Heterocysts basal and intercalary

A Filaments 9-12 mic. in diameter, scarcely thickened at base **C. æruginea**

B Filaments 15-18 mic. in diameter; false branches solitary **C. prolifera**

C Filaments 12-21 mic. in diameter; false branches fasciculate at the apex of the filament **C. fasciculata**

D Filaments 12-24 mic. in diameter; false branches in pairs, arising between two heterocysts **C. vivipara**

E Filaments 10-40 mic. in diameter, interwoven at base, decumbent **C. pilosa**

F Filaments 12-40 mic. in diameter; sheaths yellowish brown **C. crustacea**

2 Plants living in fresh water

(1) Plants epiphytic

A Filaments 5-7.5 mic. in diameter; trichomes 3.4-4 mic. in diameter **C. epiphytica**

B Filaments 7-8 mic. in diameter; heterocysts basal, usually in pairs **C. scytonemicola**

C Filaments 8-10 mic. in diameter; trichomes 6-9 mic. in diameter, especially constricted at joints; heterocysts basal, in pairs **C. stagnalis**

D Filaments 10-12 mic. in diameter, curved and bulbous-inflated at the base; trichomes 7-8 mic. in diameter **C. fusca**

E Filaments 5-15 mic. in diameter, sometimes thicker at the base; trichomes 3.5-5.5 mic. in diameter **C. sandwicensis**

F Filaments 15-16 mic. in diameter at base; sheaths thick, lamellose, finally becoming brownish black; cells very short **C. breviarticulata**

G Filaments 15-18 mic. in diameter; sheaths wide, often truncate, almost colorless; trichomes 7-9 mic. in diameter **C. violacea**

H Filaments 18-24 mic. in diameter; sheaths thick, gelatinous, lamellose, finally ocreate **C. adscendens**

(2) Plants living in warm or hot water

A Filaments 8-10 mic. in diameter; sheaths somewhat thick, uniform, transparent, sometimes yellowish at base; heterocysts basal, rarely intercalary **C. thermalis**

B Filaments 8-10 mic. in diameter; sheaths close, ocreate, transparent, becoming yellowish brown; heterocysts basal and intercalary, spherical or quadrate **C. calida**

C Filaments 10-11 mic. in diameter; sheaths close, thick, lamellose, ocreate, transparent and yellowish **C. kuntzei**

(3) Plants living on stones and wood

A Filaments 9-10 mic. in diameter; sheaths narrow, close, uniform, colorless; trichomes 6-7 mic. in diameter **C. braunii**

B Filaments 10-12 mic. in diameter; sheaths thick, close, uniform or ocreate, yellowish brown **C. parietina**

C Filaments 12-13 mic. in diameter; sheaths thin, close, uniform, colorless or yellowish **C. castellii**

Genus DICHOTHRIX

Plate XXVII, Fig. 75

Plant mass cæspitose, penicillate or pulvinate; filaments more or less dichotomously branched; trichomes often several (two to six) enclosed within the original sheath or common tegument; heterocysts sometimes basal, sometimes intercalary, in one species not present.

I. Plants living in fresh water

1 Sheaths close, gradually tapering at the apex

(1) Plants living in hot water; filaments 15-25 mic. in diameter, trichomes 5-6 mic. in diameter **D. montana**

(2) Filaments 10-12 mic. in diameter, flexuous, erect, radiating **D. orsiniana**

(3) Plant mass encrusted with calcium carbonate; filaments 9-12.5 mic. in diameter, prostrate, not rigid **D. calcarea**

(4) Plants living in fresh or rarely salt water; filaments about 15 mic. in diameter; trichomes 5-9 mic. in diameter, constricted at joints **D. baueriana**

(5) Filaments 12-15 mic. in diameter; trichomes 10-15 mic. in diameter, not constricted at joints **D. olivacea**

2 Sheaths lamellose, funnel-shaped at apex

(1) Filaments 9-12 mic. in diameter; trichomes 6 mic. in diameter **D. compacta**

(2) Filaments 13 mic. in diameter; trichomes 6.5-7.5 mic. in diameter **D. meneghiniana**

(3) Plant mass usually encrusted with calcium carbonate; filaments 15-18 mic. in diameter; trichomes 6-8 mic. in diameter **D. gypsophila**

(4) Filaments 25-28 mic. in diameter; trichomes 10-12 mic. in diameter, bulbously inflated at the bases of the branches; heterocysts light blue in color **D. hosfordii**

II. Plants living in salt water

1 Filaments 15-22 mic. in diameter, trichomes 7-9 mic. in diameter; heterocysts basal **D. rupicola**

2 Filaments 20-30 mic. in diameter; trichomes 17-22 mic. in diameter; heterocysts basal and intercalary **D. fucicola**

3 Filaments 25-35 mic. in diameter; trichomes 15 mic. in diameter; heterocysts oblong, solitary **D. penicillata**

4 Filaments 22-30 mic. in diameter; trichomes 7.5-12.5 mic. in diameter; heterocysts basal and intercalary **D. utahensis**

Genus POLYTHRIX

Plant mass filiform, branched, consisting of numerous filaments fasciculately arranged, included within a common tegument; filaments densely crowded, branched; heterocysts terminal and intercalary.

Trichomes 5-6 mic. in diameter, tapering into a thin hair at the apex; heterocysts somewhat spherical **P. corymbosa**

Genus SACCONEMA

Plate XXVIII, Fig. 76

Plant mass or colony small, gelatinous, lobed or torn; common tegument lamellose, very much folded and saccate, finally dissolved at apices, containing from two to many trichomes; trichomes irregularly aggregated, somewhat cæspitose; false branches short, moniliform, not coalesced; heterocysts basal, spherical; gonidia present.

Trichomes 8 mic. in diameter; heterocysts basal, spherical; gonidia 15 mic. in diameter; wall of gonidium roughened **S. rupestre**

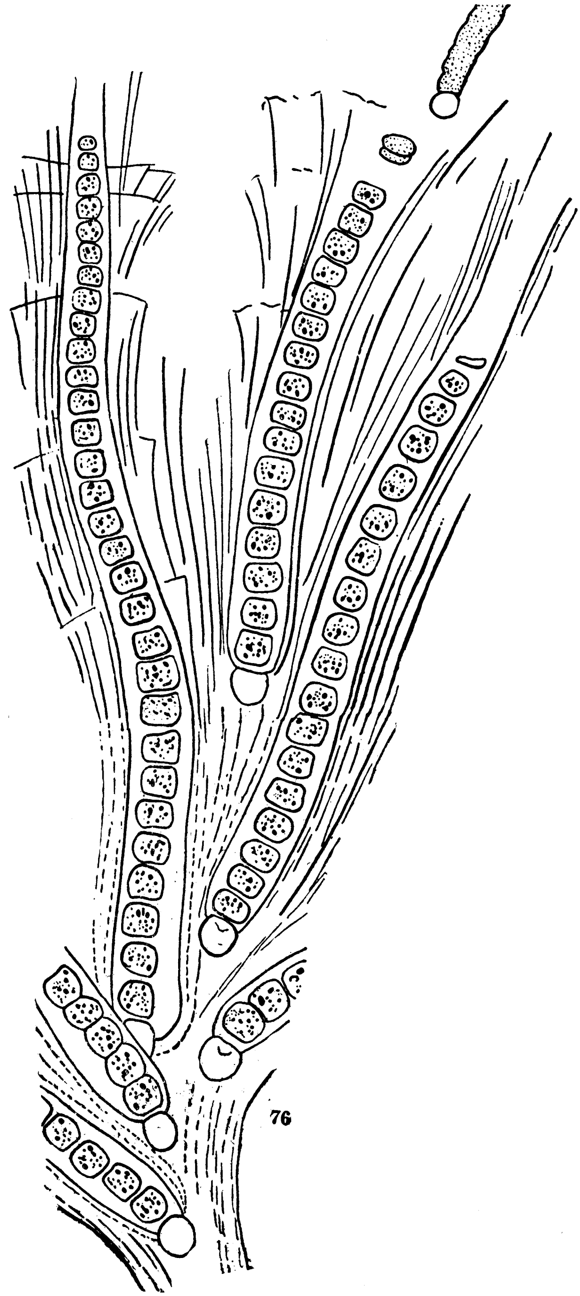

PLATE XXVIII

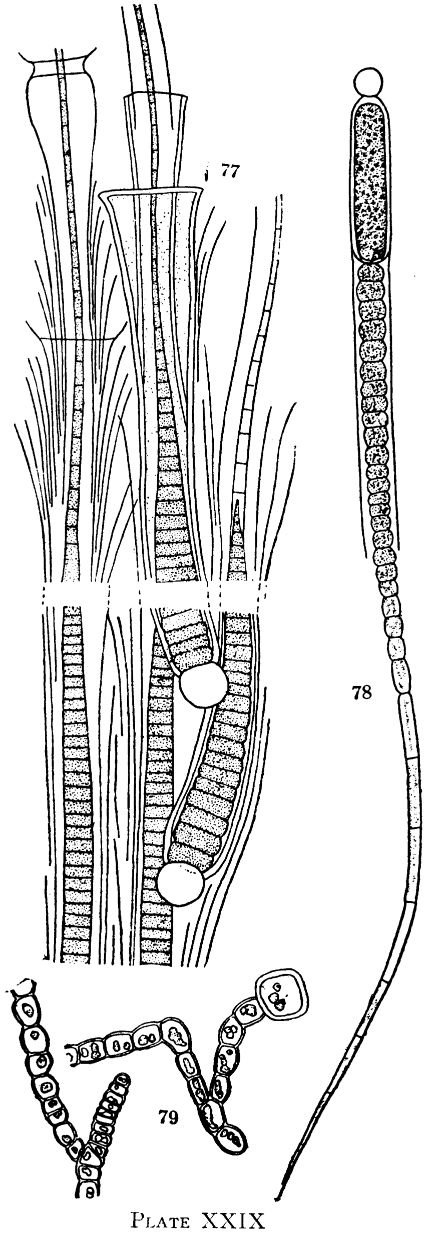

PLATE XXIX

Genus **ISACTIS**

Plate XXIX, Fig. 77

Plant mass flat, crustaceous, orbicular, thin, adhering by the lower surface, growing at the margin; filaments parallel, erect, unbranched or rarely sparingly branched; heterocysts basal; gonidia unknown.

I. Filaments decumbent at base; trichomes 7-9 mic. in diameter **I. plana**

II. Filaments slightly swollen at base; trichomes 8-10 mic. in diameter **I. centrifuga**

Genus **RIVULARIA**

Plate XXIX, Fig. 78

Colonies spherical, hemispherical or inflated and lobed, solid or hollow, sometimes confluent into an indefinite mass; filaments radiating from the center, repeatedly branched; sheaths conspicuous near the base of the trichomes, near the periphery of the colony gelatinous and confluent; heterocysts basal; gonidia more or less cylindrical and elongate, not known in all species.

I. Filaments flagelliform, tapering towards the apex; gonidia present
  1 Colonies hard; trichomes 4-7 mic. in diameter; gonidia 9-15 mic. in diameter, especially cylindrical **R. pisum**
  2 Colonies soft; trichomes 7-9 mic. in diameter; gonidia 10-18 mic. in diameter, larger at the base **R. natans**
  3 Colonies firm, solid, light green; gonidia cylindrical, frequently curved, about nine times as long as broad **R. incrustata**
  4 Colonies soft, solid; trichomes 8-10 mic. broad at the base; gonidia 8-18 mic. in diameter, cylindrical, straight or slightly curved **R. echinulata**

II. Filaments gradually tapering; gonidia unknown
  1 Colonies hollow when old
    (1) Colonies soft; trichomes 4-5 mic. in diameter in lower portion, somewhat constricted at joints **R. polyotis**
    (2) Colonies soft; trichomes 2-5 mic. in diameter, cylindrical **R. nitida**
  2 Colonies solid
    (1) Colonies not encrusted with calcium carbonate
      A Plants living in fresh water
        a Trichomes 4 mic. in diameter **R. borealis**
        b Trichomes 6-10 mic. in diameter **R. compacta**
        c Trichomes 9-12.5 mic. in diameter **R. minutula**

d Trichomes continuous or indistinctly divided; heterocysts 10-12 mic. in diameter **R. paradoxa**

B Plants living in salt water; trichomes 2.5-5 mic. in diameter **R. atra**

(2) Colonies encrusted with calcium carbonate

A Colonies hemispherical, finally confluent and forming a hard, stony crust; trichomes 4-7.5 mic. in diameter **R. hæmatites**

B Colonies small, somewhat hard; trichomes 4-9 mic. in diameter **R. dura**

C Colonies at first hemispherical, afterwards forming a gelatinous crust, indurated with calcium carbonate in the interior; trichomes 5-9 mic. in diameter **R. coadunata**

D Colonies spherical, hard; trichomes 4-16 mic. in diameter **R. bornetiana**

Genus BRACHYTRICHIA

Plate XXIX, Fig. 79

Colonies at first solid, finally becoming hollow, made up of Nostoc-like filaments embedded in gelatin; filaments flexuously curved, parallel, above tapering and drawn out into a hair at the apex, very much branched; sheaths distinct in the young filaments, tubular, finally becoming confluent and invisible; heterocysts intercalary, arranged without any order.

Colonies up to 5 cm. in diameter, plicate-expanded and bullate, confluent, blackish green. **B. quoyi**

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GLOSSARY

The proper terms to be used in connection with the blue-green algæ have not yet become definitely established. The terms and definitions given in this synopsis are merely provisional, in case better ones can be found. Some difficulty has been experienced with the terms: "plant mass," "colony," "family," "thallus," etc. The definition of each, as the author conceives the meaning, is given in the glossary.

Plant mass, the usually shapeless mass of individual plants remaining in close proximity to each other after their formation, either because nothing occurs to separate them or because they are definitely held together by a gelatinous excretion

Colony, a mass of plants of more or less definite shape, large enough to be detected by the naked eye

Family, a mass of plants of microscopic size and somewhat definite shape, quite evidently arising from the division of a single cell

Plant, in the COCCOGONEÆ a single cell; in the HORMOGONEÆ a single trichome. In the latter case it may be thought better by some to consider "plant" and "filament" as synonymous terms.

Adherent, clinging to, or united with

Adnate, touching closely or broadly

Agglutinated, glued together

Aggregated, forming a mass or collection, but not cohering

Amorphous, structureless

Anastomose, to run together in a netlike manner

Angular, having angles; sharp cornered

Apex, the end opposite the point of attachment; tip

Appressed, pressed closely against

Approximate, near, about

Aquatic, living in water

Arachnoid, cobwebby

Articulate, jointed with cells

Asexual, without sex

Base, the point of attachment

Brackish, somewhat salty

Bulbous, with a bulb

Bullate, swollen

Bullose, swollen

Cæspitose, in tufts or dense bunches

Calcareous, composed of or containing lime

Calyptra, a cap or lid

Capitate, furnished with a globose head

Carneous, fleshy

Cartilaginous, firm and tough like cartilage

Catenate, joined in a continuous series; in a chain

Cell, a closed sac, surrounded by a wall of cellulose, containing protoplasm and a single nucleus

Cell sap, the watery fluid of a cell which separates from the protoplasm as one or more vacuoles

Cell wall, the membrane enclosing the cell contents

Cellulose, the cell wall substance of plants

Centrifugally, from the center

Centripetally, toward the center

Chlorophyll, the green coloring matter contained in plants; leaf-green

Chromatophore, a plastid, containing a coloring matter

Cilium (pl. **cilia**), one of the vibratile, protoplasmic processes which serves to propel zoogonidia through the water

Circinate, rolled from the end

Clathrate, with openings like lattice work

Clavate, club-shaped

Coalesced, grown together, united

Coalescence, the complete union of similar things

Collateral, side by side, secondary

Colony, a group of independent cells surrounded by a common investment; a mass of plants of more or less definite shape, large enough to be detected by the naked eye

Concentric, with a common center

Confluent, growing or running together

Conidium, gonidium; a gonidium which is abstricted from the apex of a stalk

Constricted, narrowed in certain places

Contiguous, near or in contact

Contorted, twisted

Contractile, able to contract

Convolute, rolled together

Coriacious, leathery, tough

Crenate, wavy

Crisped, curled

Crustaceous, crust-like

Cuspidate, pointed, with a tooth

Decumbent, lying down

Deliquescent, dissolving

Dense, crowded together

Depressed-globose, globular, with the poles slightly flattened

Dichotomous, two-forked; furcate

Dichotomy, division into two branches

Diffluent, dissolving

Disc, any flat circular area

Disc-shaped, flat and circular
Dissepiment, cross wall
Distal, pertaining to the apex
Divaricate, spreading
Diverging, separating
Eccentric, without a common center
Elongate, lengthened, very long
Endophyte, a plant living within another organism, usually as a parasite
Entire, not toothed
Epiphyte, a plant growing upon the outside of another plant, but not nourished by it
Equilateral, with equal sides
Family, a mass of plants of microscopic size and somewhat definite shape quite evidently arising from the division of a single cell
Fascicle, bundle
Fasciculate, in bundles
Fastigiate, tapering to a point
Fenestrate, window-like
Fibrillæ, little threads
Fibrillose, made up of small fibers
Fibrous, of fibers
Filament, the trichome together with its sheath; a fine thread
Filamentous, thread-like, composed of filaments
Filiform, thread-shaped
Fission, splitting; cell division in which cell separates into two nearly equal portions, especially as a mode of reproduction
Flaccid, soft, flabby
Flagelliform, whip-like
Flexuous, flexible
Floccose, composed of matted, woolly hairs
Flocculent, woolly
Foliaceous, leaf-like
Foliose, leaf-like
Gelatinous, jelly-like
Geminate, paired
Geniculate, bent abruptly like a bent knee
Genuflexuous, bent abruptly
Glaucous, sea-green, gray-green
Globose, like a ball
Globular, spherical or nearly so
Gonidangium, the cell in which gonidia are produced
Gonidium, a reproductive cell developed asexually; a specialized reproductive cell capable by itself of giving rise to a new organism
Granular, with granules
Granule, a small grain
Granulose, with granules
Gregarious, growing in association, but not matted together
Grumose, **grumous**, like a cluster of grains
Habit, the general appearance or characteristic manner of growth of a plant
Habitat, the locality or region, or the kind of situation in which a plant is naturally found
Heterocyst, a cell uniformly larger than its neighbors, but of doubtful function
Hirsute, with coarse hairs
Homogeneous, uniform in character or substance
Hormogone, a short chain of cells broken off from a mature plant, by means of which vegetative multiplication is effected
Host, a plant which supports a parasite (or an epiphyte?)
Hyaline, clear and colorless, transparent
Immersed, sunken below the surface
Impregnated, filled with
Indurated, hardened
Inequilateral, with unequal sides
Inflated, swollen
Integument, any outer covering
Intercalary, inserted between
Intricate, tangled, involved
Inundated, flooded
Investment, a covering
Laciniate, torn
Lacunose, hollowed
Lamelliform, plate-like
Lamellose, with plates or blades
Lenticular, lens-shaped
Lubricous, slippery, slimy
Lumen, cavity
Mammillate, mammillose, with nipple-like projections
Mammilliform, nipple-like
Marginal, at the edge
Membranaceous, papery
Moniliform, chain-like

Motile, able to move
Mucilaginous, jelly-like
Multicellular, of several to many cells
Nodule, a little knot or lump
Nucleus, a differentiated round or oval body embedded in the protoplasm of a cell
Obovate, ovate, but with the point of attachment at the lower end
Ocrea, a sheath
Ocreated, sheathed
Orbicular, circular
Oval, elliptical
Ovoid, egg-shaped
Pannose, ragged
Papillose, with a little point or nipple
Parasite, a plant that lives on or in some other organism from which it derives its nourishment for the whole or a part of its existence
Parenchyma, the soft, thin-walled cellular tissue of plants
Pedicel, a small or delicate supporting stalk
Pedicellate, stalked
Pellucid, clear
Penicillate, like a brush
Periphery, edge
Phycocyanin, a blue pigment contained in the chromatophores of the blue-green algæ
Pigment spot, a specialized mass of cytoplasm permeated by a red coloring matter, present in the motile cells of many algæ; eyespot
Piliferous, bearing hairs
Pilose, hairy
Plant, in the COCCOGONEÆ a single cell; in the HORMOGONEÆ a single trichome
Plant mass, the usually shapeless mass of individual plants remaining in close proximity to each other after their formation, either because nothing occurs to separate them or because they are definitely held together by a gelatinous excretion
Plicate, folded or ridged
Polar, at the end
Polygonal, many-sided
Polyhedral, many-angled
Polymorphous, of many forms
Proliferated, grown out
Protoplasm, the viscid, contractile, semiliquid, more or less granular, substance that forms the principal portion of an animal or vegetable cell
Prostrate, flat, lying down
Pseudo-parenchymatous, like parenchyma
Pubescent, finely hairy
Pulverulent, powdery
Pulvinate, cushion-like
Punctate, dotted
Punctiform, dot-like
Pustular, like a swelling
Pyrenoid, a small colorless mass of proteid substance seen in many algæ, which may be regarded as reserve material
Quadrate, square, in fours
Radial, pertaining to a radius, as of a circle or sphere
Rectilinear, straight
Refractive, refringent, bending or turning aside as a light ray
Reniform, kidney-shaped
Reproduction, the development of one or more new organisms from the whole or from a part of the protoplasm of a parent organism
Rotund, round
Rugose, furrowed, roughened
Saccate, sack-like
Segment, one of the parts into which an object is naturally divided
Septate, divided by partitions
Seriate, in a row
Sessile, without a stalk
Sheath, a gelatinous, usually tubular, envelope surrounding a plant
Silicious, containing silica
Sinuate, snake-like, twisted
Sinus, a gulf or indentation
Spatulate, shaped like a spoon
Spherical, ball-like
Spongiose, spongy
Stellate, star-like
Stratified, in layers
Stratum, a layer
Striated, having fine markings
Sub, slightly, somewhat
Submerged, sunken
Substratum, surface on which the plant grows

Superposed, placed one above another
Tegument, covering
Tenacious, firm, tough
Terebriform, screw-like
Terminal, end
Terrestrial, growing on the ground
Thallus, a plant-body without true root, stem or leaf; used incorrectly instead of "plant mass"
Tomentose, closely hairy
Tortuous, twisted
Torulose, chain-like
Trichome, the entire number of cells of a multicellular plant, not including the sheath
Truncate, cut off abruptly
Tuberculate, tuberculose, warted
Tubular, tube-like
Ultimate, last end
Uncinate, hooked at the end
Undulate, wavy
Unicellular, one-celled
Unilateral, one-sided
Vacuole, a cavity containing a watery fluid in the protoplasm of a cell
Ventricose, a swelling out on one side or in the middle
Verrucose, warted
Vesicle, a small bladder-like cavity
Vesicular, bladdery
Villous, long hairy
Zonate, disposed in the form of zones

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